



EU funds  
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2014-2020



MASTER OF SCIENCE  
IN INFORMATION  
TECHNOLOGY AND  
SYSTEMS



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MASTER OF SCIENCE  
IN INFORMATION  
TECHNOLOGY AND  
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# V2 PROGRAMME SPECIFICATIONS



Operational Programme II – European Structural and Investment Funds 2014-2020  
*“Investing in human capital to create more opportunities and promote the well-being of society”*

Project part-financed by the European Social Fund  
Co-financing rate: 80% European Union; 20% National Funds



## MCAST Master of Science in Information Technology and Systems

MQF Level 7

90 ECTS

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### Programme Rationale

The Master of Science in Information Technology and Systems programme is an effective means of opening up new career possibilities in a broad range of ICT fields. Graduates of this Master programme will have the knowledge and skills to solve complex social, economic and technical problems within the context of information and communication technology. This Master programme will deliver theoretical and practical knowledge in specific areas to establish the academic, engineering and skill proficiency level required and expected by a professional to a productive role at a global level in the development of the Information Technology and Systems industry. The Master of Science in Information Technology and Systems programme provides fundamental skills in a variety of advanced ICT areas such as Big Data; Internet of Things (IoT), with a focus on developing intelligent solutions with a mix of hardware and software; Software as a service infrastructure; Information Management; Enterprise Systems; eLogistics; Systems Strategy and Management; Business Process Innovation; Cyber Security; Network Security and Data Management Technology, as well as Software defined networking, and the new field of distributed hashing and computing, typified by distributed version control systems and cryptocurrency applications. The programme delivers innovative and well-founded qualification and applied skills for the next generation of information systems designers and software architects respecting and integrating relevant aspects of innovation management and entrepreneurship. Information technology and systems is a composite engineering discipline with the core

identity in the design, integration and maintenance of computation, communication and business management systems. All of the three systems are of extreme complexity and as such must be approached in a manner that differs from the traditional engineering disciplines like mechanical or chemical engineering.

This programme is conceptualised as a compact and yet comprehensive and practical body of education and training material necessary to prepare a graduate learner for the cutting-edge information systems and technologies relevant job openings in the labour market of the European Union, with specific attention to the Malta's high tech labour market.

Particular units of the programme are devoted to the development of the entrepreneurship skills, working skills development and understanding of modern business computerised financials and e-commerce. Facing the aggressive expansion of global e-commerce activities, Malta's high tech labour force must be ready for the future developments that may take place faster than anticipated.

## Programme Learning Outcomes

Upon successful completion of this Master's Programme, the learner will be able to:

1. Master proficiency in two complementary problem domains; information technology and business management domains;
2. Use the acquired technical and business problem analysis skill set and most effectively propose information system design matched to the documented business needs;
3. Select adequate technical means to design a solution that not only solves the specified technical and business problem, but also be extensible in the future in response to any additional needs of the growing business organisation;
4. Design an information system that optimally matches a specified purpose and business system role while minimising design effort and implementation costs;
5. Build systems features that make the overall system use, administration and



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- maintenance team-friendly;
6. Perform adequate reengineering of existing information technology powered business systems and design complementary subsystems to enhance business efficiency;
  7. Synchronise existing international, European, and domestic standards with the custom developed solutions;
  8. Prepare a business plan;
  9. Structure a start-up enterprise;
  10. Design new product/service marketing plan using modern Web technologies;
  11. Use predictive analytical methods and big data processing to define the market for a new product or service;
  12. Structure, budget, and execute a fundraising campaign needed for growing a start-up enterprise.

## MQF Level Descriptors for Level 7

|                        | Level 7 EQF                                                                                                                                                                                                                              | Level 7 MQF                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Level Knowledge</b> | Highly specialised and is at the forefront of knowledge in a field of work or study as the basis for original thinking and/or research. Critical awareness of knowledge issues in a field and at the interface between different fields. | <ol style="list-style-type: none"><li>1. Has comprehensive knowledge and understanding that is founded upon and/or enhances that knowledge typically associated with Bachelor's level;</li><li>2. Uses specialised or multi-disciplinary theoretical and practical knowledge some of which is at the forefront of a field of study. This knowledge forms the basis of originality in developing and/or applying ideas.</li></ol> |



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|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Skills</b>            | Specialised problem-solving skills required in research and/ or innovation in order to develop new knowledge and procedures and to integrate knowledge from different fields.                                                                              | <ol style="list-style-type: none"> <li>1. Demonstrates specialised or multi-disciplinary knowledge that include reflecting on social and ethical responsibilities linked to the application of one's knowledge and judgements;</li> <li>2. Can communicate to specialist and non-specialist audiences clearly and unambiguously reach conclusions which may be the outcome of research, self-study or experience;</li> <li>3. Performs critical evaluations and analysis with incomplete or limited information to solve problems in new or unfamiliar environments and produces original research;</li> <li>4. Develops new skills in response to emerging knowledge and techniques and demonstrates leadership skills and innovation in complex and unpredictable work and study contexts.</li> </ol> |
| <b>Competencies</b>      | Manage and transform work or study contexts that are complex and unpredictable that require new strategic approaches. Take responsibility for contributing to professional knowledge and practice and/or for reviewing the strategic performance of teams. | <ol style="list-style-type: none"> <li>1. Creates a research-based diagnosis to problems by integrating knowledge from new or interdisciplinary fields and makes judgements with incomplete or limited information;</li> <li>2. Manages people and projects and demonstrates the ability to respond to the fast-changing business environment;</li> <li>3. Demonstrates autonomy in the direction of learning and a high level of understanding of learning processes;</li> <li>4. Has the learning skills to allow continuation to study in a manner that may be largely self-directed or autonomous.</li> </ol>                                                                                                                                                                                       |
| <b>Learning Outcomes</b> | <ol style="list-style-type: none"> <li>1. Knowledge and Understanding;</li> <li>2. Applying Knowledge and Understanding;</li> <li>3. Communication Skills;</li> <li>4. Judgmental Skills;</li> <li>5. Learning Skills;</li> </ol>                          | <ol style="list-style-type: none"> <li>1. Has the comprehensive specialised or multi-disciplinary theoretical and practical knowledge which forms the basis of original research, which may contribute to social and ethical issues;</li> <li>2. Demonstrates capability in using knowledge and skills, to adapt to the fast-changing business environment and to manage people and projects efficiently;</li> </ol>                                                                                                                                                                                                                                                                                                                                                                                    |



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|  |                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | 6. Autonomy and Responsibility. | <p>3. Communicates with specialist and non-specialist audiences clearly and unambiguously reaches conclusions which may be the outcome of original research, self-study or experience;</p> <p>4. Performs critical evaluations and analysis with incomplete or limited information to solve problems in new or unfamiliar contexts, and produces original research;</p> <p>5. Makes assessments of personal continuous professional development, takes initiative to undertake self-directed study and may proceed to further specialisation;</p> <p>6. Is accountable and responsible for the original research within a personal social responsibility and/or business context for one's operations and for adapting the management of people and projects reflecting the dynamic nature of the environment in which one operates.</p> |
|--|---------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

*Referencing Report - National Commission for Further and Higher Education. 4<sup>th</sup> Revised Edition February 2016*



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## Overview of Study Units

### First Year (Semesters 1 & 2: 30 ECTS)

1. Information Systems and Management
2. Operating Systems and Cloud Computing
3. Network Protocols and Network Automation
4. Data Science and Predictive Analysis
5. Foundations of Cyber Security

### Second Year (Semesters 3 & 4: 30 ECTS)

6. Web Technologies and Secure E-Commerce
7. Mobile Computing and 5G Networking
8. Internet of Things (IoT)
9. Financial Computing and Cryptocurrencies
10. Entrepreneurship and Innovation Management

### Third Year (Semesters 5: 30 ECTS)

Dissertation



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## STUDY UNIT 1

### Information Systems and Management

MQF Level 7

6 ECTS

E-learning: No

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### Rationale

This unit takes a critical approach to computing-enabled business management while guiding the learners on how to take practical steps when implementing information technologies to support modern business management and critical decision-making.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Demonstrate analytical skills, when conducting pre-design meetings with the business organisation staff;
2. Utilise UML use case diagrams in technical and business problem analysis as part of the preparation for a structured approach to complex problem solving;
3. Design a business organisation management UML and structure diagram, and determine the key persons as points of contact (PoC) and/or decision (PoD);
4. Analyse and determine the business information processing and communication needs necessary to achieve a business competitive advantage;
5. Prepare for, and conduct the evaluation of strategic technical alternatives;
6. Communicate strategic alternatives to facilitate upper management for taking informed decisions;



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7. Apply acquired knowledge, analysis and design skills to facilitate the acquisition, design, development, deployment, and management of an information system in a given business enterprise or government-related organisation.

## Content – Detailed

1. This introductory unit clarifies the frequently misleading interpretations of concepts such as data, information, data codes and data processing. Initially, the human experience of data and data types defines how data will be encoded in computing systems. Data and information are well defined by Claude Shannon, founder of information theory. Computing codes and understanding data is essential for the comprehension of general data processing that has resulted in the business applications of computing and business data processing as we know it today. This unit highlights the importance of a business decision support system and a relevant operations support system (BSS/OSS).
2. Understanding business fundamentals in the application of information, computation and communication technologies (ICT) to real world problems such as running a business organisation is elaborated upon in this unit. Subjects include: the concepts of trading and market mechanisms, business organisational and operational activities, the definitions of market, market positioning and business planning with the basic legal business forms. Business record keeping, internal business data processing for taxation and operation purposes are also covered. Business ethics is highlighted as being as important as profitability.
3. Office management procedures and relevant software applications are the subject of the third unit. Corporate departments such as sales, purchasing,

warehouse, shipping, inventory, marketing, legal, engineering, logistics, sales management, etc, are identified as corporation organisational units. Office automation systems (OAS), which are also relevant, present options such as Software as a Service (SaaS) implemented in the public or private cloud. Microsoft Office Suite's main members such as Word, Excel, Access and PowerPoint are highlighted as well as their practical application to office automation. The use of presentation tools and skills to prepare an effective business meeting with office collaboration automation tools is introduced to learners as future business founders, owners or managers.

4. This topic deals with the corporate structure of large scalable systems as well as with the fundamentals of small business organisation structure, an important topic for the potential founder of the small business. Organisation structure, organisational charts and the tools needed to produce charts are introduced. The roles of chief officers, such as executive (CEO), technology (CTO), financial (CFO), information (CIO), and security (CIO) are discussed, along with their duties and responsibilities. Particular attention is devoted to the ownership structure, the board of directors, management organisation, labour division and customer relations. An overview of the enterprise information system based on intranet technology is also covered.
5. Analysis, modelling and the design of complex systems such as corporate systems and management information systems (MIS) are the subject of this unit. Systems object technologies and UML, looking at the specifics and generalities in complex problem analysis and use case analysis, identifying actors and subsystems. Exploring object diagrams (time-sequence and space-collaborative) and class diagrams (aggregation, composition, inheritance, relationships) and how they provide clear insight into a complex business organisation. Business models and design patterns are presented as a concluding topic of knowledge reusability methods.

6. The main topic of this lesson is management information systems (MIS) as an ICT-based core element of a modern business organisation. Subjects include: information technology infrastructure library (ITIL) and practices for IT service management (ITSM), transaction processing and record keeping, service level agreements (SLAs), information systems by departments (OAS, DSS, EIS and BI, etc.), planning and design of corporate computing infrastructure (real, cloud and virtualised computing and networking systems) as well as the relevant emerging technologies in IT infrastructure.
7. E-business and e-logistics are inevitable elements within modern business. In synergy with e-commerce, the concepts of digital goods, digital services and digital markets will be covered. Other topics include: flexible human resource management in the cyber age, labour flow as a logistic process based on ICT technologies, space cost reduction, warehousing storage, production storage, and distribution and services management within the logistic network of supply and support chains. The concept of modern low cost virtual business with all resources being outsourced, global e-business collaboration and business world integration will be the concluding topics.
8. Help desk engineering, office automation application distribution, software assets inventory and the update management of all corporate application software packages are covered in this topic. System updates and the upgrade synchronisation of the versions being used, plus the importance of in-house and outsourced training and support will be reviewed as important elements of the modern business environment.
9. Corporate governance starting with the fundamentals of governance will be covered in this lecture. The basics of business intelligence applied to decision support systems with the options of automating the decision-making process are considered. Following up on this topic we will look at: managing decision making, (support, expert and executive MIS), an introduction to securing

information systems (covered in more detail in a following unit), maintaining repositories of all technical and managerial documentation as the essence of a successful modern organisation, and finally archiving and managing knowledge automation as an important MIS element (which is commonly neglected in courses on MIS).

10. As an element of governmental MIS systems, e-government is the main topic of this concluding lecture. The application of information and communication technologies (ICT) to governmental citizen's services automation is discussed. International ICT standards applied to the design and implementation of e-government MIS systems. In addition, the four stages of electronic government development and integration of e-government MIS systems with a managed global e-government system will be covered. Ethical and social issues in the application of information systems in e-government with some recommendations will be presented at the end of this lecture and unit.

## Assessment Criteria

| Learning Outcomes                                                                                                                                            | Assessment Criteria                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                             | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                                      |
| 1. Demonstrate analytical skills, when conducting pre-design meetings with the business organisation staff.                                                  | 1.1 Apply active listening skills during a pre-design meeting.<br>1.2 Organise notes taken during the meeting.<br>1.3 Discuss key points.<br>1.4 Summarise the follow up steps upon meeting completion.<br>1.5 Precisely document a given problem and explain the input of the various design stages of a design process. |
| 2. Utilise UML use case diagrams in technical and business problem analysis as part of the preparation for a structured approach to complex problem solving. | 2.1 Compile a system organisational problem in one sentence.<br>2.2 Pose key questions and conduct a use case analysis of the systems activity at hand.<br>2.3 Classify key entities and model their interactions and dependencies.<br>2.4 Produce completed analysis documentation.                                      |



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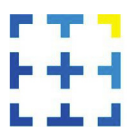


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| 3. Design a business organisation management UML and structure diagram, and determine the key persons as points of contact (PoC) and/or decision (PoD).                                                                            | <p>2.5 Graphically present a system design structure.</p> <p>3.1 Identify a key person as a point of contact for information exchange.</p> <p>3.2 Identify a key decision maker as a point of decision for conclusions approval.</p> <p>3.3 Design a business management structure chart.</p> <p>3.4 Discuss and interpret the individual business structure element roles.</p> <p>3.5 Explain and rationalise a given business organisation structure.</p> |
| 4. Analyse and determine the business information processing and communication needs necessary to achieve a business competitive advantage.                                                                                        | <p>4.1 Document a given business organisation structure.</p> <p>4.2 Specify the communication capacities needed for internal and external communications.</p> <p>4.3 Identify and differentiate between vendors of voice and data communication services.</p>                                                                                                                                                                                               |
| 5. Prepare for and conduct the evaluation of strategic technical alternatives.                                                                                                                                                     | <p>5.1 Evaluate business strategic goals and identify key existing competitors.</p> <p>5.2 Specify possible future competitors.</p> <p>5.3 Propose and differentiate between alternative business strategy to gain a competitive edge.</p> <p>5.4 Specify the tactics matching the strategy.</p>                                                                                                                                                            |
| 6. Communicate strategic alternatives to facilitate upper management for taking informed decisions.                                                                                                                                | <p>6.1 Produce documentation describing the findings in regard to strategies and tactics.</p> <p>6.2 Effectively present documented data.</p> <p>6.3 Argue in defence of proposed strategy and tactics.</p>                                                                                                                                                                                                                                                 |
| 7. Apply acquired knowledge, analysis and design skills to facilitate the acquisition, design, development, deployment, and management of an information system in a given business enterprise or government-related organisation. | <p>7.1 Produce a repository of analysis, design and strategic planning data.</p> <p>7.2 Document proposed management information system design solutions.</p> <p>7.3 Conduct a cost benefit analysis for a proposed system.</p> <p>7.4 Explain the ethical standing of a business and the relevant ICT practices.</p> <p>7.5 Integrate a business information management system with eGovernment systems.</p>                                               |





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## Assessment Methodology

| Assessment Criteria Covered | Assessment Scenario                                                                                                                                                                                                       | Assessment Method                                                                                                         | Grading Info (optional)                                   |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| 1.1 - 1.5                   | Perform a simulated or real engineering business meeting or watch a video of a meeting. Produce relevant written documents.                                                                                               | Review of the written documents and matching the portions of the documents with the learning objectives. (Weighted at 7%) | All matched assessment criteria earns a total of 7 points |
| 2.1 - 2.5                   | Perform a sample small business use case analysis, and UML modelling. Produce a written report.                                                                                                                           | Review of the written documents and matching the portions of the document with the learning objectives. (Weighted at 7%)  | Each matched assessment criteria earns 7 points           |
| 3.1 - 3.5                   | Analyse a college as a business organisation and as an organisational structure. Produce a written report.                                                                                                                | Review of the written documents and matching the portions of the document with the learning objectives. (Weighted at 7%)  | Each matched assessment criteria earns 7 points           |
| 4.1 - 4.3                   | Itemise all the ICT requirements of a small and a large business organisation. Find out the costs in a local context.                                                                                                     | Review of the written documents and matching the portions of the document with the learning objectives. (Weighted at 7%)  | Each matched assessment criteria earns 7 points           |
| 5.1 - 5.4                   | Use the Web and analyse one type of business, e.g., cell phone manufacturing. Explain why one business is the leader in that particular industry.                                                                         | Review of the written documents and matching the portions of the document with the learning objectives. (Weighted at 8%)  | Each matched assessment criteria earns 8 points           |
| 6.1 - 6.3                   | Study samples of upper management reports and a focal-points presentation. Produce a PowerPoint presentation of the simulated report on the proposed management information system architecture for the upper management. | Review of the written documents and matching the portions of the document with the learning objectives. (Weighted at 7%)  | Each matched assessment criteria earns 7 points           |



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|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| 7.1 - 7.5    | Answer a list of questions regarding eGovernance and eGovernment. Propose the best way to integrate an internal business information system with the public eGovernment system. | Review of the written documents and matching the portions of the document with the learning objectives. (Weighted at 7%) | Each matched assessment criteria earns 7 points                       |
| Midterm test | Answer a list of 20 relevant questions demonstrating an understanding of the relevant terminology and concepts.                                                                 | Review the questions answered. (Weighted at 20%)                                                                         | Each question properly answered earns 1 point, (Maximum of 20 points) |
| Final test   | Answer a list of 20 relevant questions demonstrating an understanding of the relevant terminology and concepts.                                                                 | Review questions answered. (Weighted at 30%)                                                                             | Each question properly answered earns 1 point, (Maximum of 30 points) |



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## STUDY UNIT 2

### Operating Systems and Cloud Computing

MQF Level 7

6 ECTS

E-learning: Yes

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### Rationale

This unit covers core hardware and software technologies that are enable modern computing systems. As such, they represent a key element of knowledge to be mastered enabling the learner to be able to propose systems solutions when designing secure and elastic cloud computing systems and software defined data centres. Special attention is devoted to the cost-performance evaluation of traditional data centre solutions versus private, public or hybrid cloud solutions.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Conceptually distinguish operating system modules and demonstrate relevant analytical skills when conducting cost-performance evaluation of alternative hardware and software optional solutions;
2. Administer systems using systems utilities, system shell commands;
3. Automate commonly repeated systems administration tasks and maintenance routines by writing and automatic scheduling execution of shell scripts;
4. Design a storage system using a multi-tiered cache-based approach that leverages investment;
5. Consolidate a data centre hardware infrastructure by virtualisation of redundant

systems and better utilised electrical energy; be more robust to individual systems failure and be more secure;

6. Select cloud features and capabilities needed in an enterprise;
7. Build private enterprise cloud infrastructures;
8. Implement state-of-the-art cloud application performance monitoring and analytics.

## Content – Detailed

1. An overview of computing hardware platform elements is essential for the understanding and use of the systems and application software. This unit starts with the presentation of the elementary CPU architecture overview, presentation of the hierarchy of communication busses, such as internal CPU busses, systems board busses, (memory and I/O busses), and the discussion of the external networking busses as the shareable communication hardware infrastructure. Key hardware intelligence elements will be highlighted, as well as how hardware devices are attached to the systems network and how hardware devices are made available to the operating system via device drivers.
2. In the second topic of this unit, an introductory analysis of the program behaviour at runtime is given. The lecture highlights lifetime phases of a program, starting with the program behaviour at development time. Viewing programs from the administrative point of view and external program system administration using various practical tools and utilities is presented. The internal program view at run time, related to normal and abnormal program behaviour, and the fundamental concepts of program distribution based on kernel IPC services are introduced.
3. High performance multi processor servers are essential for modern data centre virtualisation and cloud computing infrastructure implementation. This topic



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covers elementary approaches to symmetric (SMP) and asymmetric (AsMP) multiprocessor architecture design, considering the pros and cons of using each approach. Multitasking and multi threading, multi-core CPU and hyper-threading, as well as SMP server architectures and performance problems are covered. High speed I/O standards, parallel I/O, I/O optimisation and an introduction to high performance computing (HPC), high performance and high capacity memory and storage system design are presented.

4. High performance memory architecture and design, as essential elements of HPC computing design solutions, are presented in this lecture. Memory controller architecture and practical configuration of parallel memory modules is described aiming at the learner's ability to fine tune hardware systems performance. Memory performance problems and large systems memory design solutions are discussed, as well as, an overview of so far futuristic, new cold memory technologies and design options.
5. Virtualisation of the computing infrastructure has been the latest trend in the implementation of computing and communications infrastructures worldwide. This modern topic is the main subject of this lecture. Being at the heart of virtualisation as the fundamental implementation concept, virtual memory management unit (VMMU) architecture is reviewed. The virtual processor based on the multi tasking and multi threading and virtual I/O devices within a virtual machine are explained. An overview of the existing technical solutions offered by different vendors is also covered.
6. In order to be able to design, implement and maintain high-performance software-defined storage systems, this lecture will expose the learner to the fundamental block nature of storage at the lowest level and the concept of a file as the highest-level storage interface. A review of legacy storage technologies and large capacity storage solutions based on the storage distribution under the common volume design and management is the core topic. In order to enhance



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storage system performance, storage caching and layered storage architecture design is considered. This topic will conclude with the application of the systems software to flexible software defined storage provisioning.

7. This topic deals with the popular notion of cloud computing. After the introduction to the fundamentals of cloud computing; reliable data filing, cloud converging systems, cloud storage architecture, and cloud access methods with the relevant [security issues](#) are covered. Data centre migration to the cloud, which almost every modern data centre management and technical administration staff faces is elaborated upon at the end of this topic.
8. Enterprise cloud computing system architecture design and implementation, from a technical perspective, is the main subject of this lecture. The cloud computing system internal structure; cloud computing network devices (real and virtual switches); cloud computing systems network design; and cloud computing access subsystem design are presented.
9. Disaster recovery (DR) strategies, procedures and cloud solutions that could be used for rapid recovery are presented in this lecture. As an introductory topic, simple backup procedures in small business organisations are presented, as well as disaster incident management procedures. Business continuity has been stressed as the most important goals of any DR strategic planning and design procedure. Best practices in business continuity assurance are presented. Technical aspects of the real time backup, live syncing of data and data migration solutions with the option of DR virtualisation are considered.
10. As a concluding topic of this study unit, the business aspects of using cloud computing solutions in modern business organisations (of any size) is considered. Leveraging cloud services and business perspective with the cost-performance equation is highlighted. Practical comparison of private, public and hybrid cloud solutions based on cost-performance analysis are presented. Existing public cloud service offerings from providers such as Amazon,



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Microsoft and Google are discussed. Cloud computing security issues are also addressed.

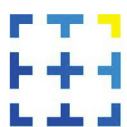
## Assessment Criteria

| Learning Outcomes                                                                                                                                                                                    | Assessment Criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                                                                     | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 1. Conceptually distinguish operating system modules and demonstrate relevant analytical skills when conducting cost-performance evaluation of alternative hardware and software optional solutions. | 1.1 Apply an active analysis of the enterprise context that has to be served with the system.<br>1.2 Organise analysis documentation.<br>1.3 Formulate a proposal and present supporting arguments in favour of the selected solutions.                                                                                                                                                                                                                                                                                                                                                                                                |
| 2. Administer systems using systems utilities, system shell commands.                                                                                                                                | 2.1 Classify key internal systems entities and model their interactions and dependencies.<br>2.2 Relate available systems internal modules to the set of shell commands with option switches and arguments needed to control pertinent modules.<br>2.3 Combine commands into a batch of commands and automate repetitive systems administration tasks.<br>2.4 Combine individual commands into a pipeline of commands and create custom commands matching the problem at hand.<br>2.5 Produce commenting documentation of the custom batch commands made.                                                                              |
| 3. Automate commonly repeated systems administration tasks and maintenance routines by writing and automatic scheduling execution of shell scripts.                                                  | 3.1 Create a script and schedule a one-time execution at the precise time.<br>3.2 Create a script and schedule a repeated execution on monthly, weekly, daily and hourly bases.<br>3.3 Build a library of non-standard command line tools and utilities, test their use and have them applied to custom systems maintenance scripts.<br>3.4 Build a library of graphical interface utilities and demonstrate their use.<br>3.5 Use GUI systems tools to evaluate systems hardware parameters.<br>3.6 Generate a report of available systems hardware elements and produce a report of their test results with all parameters measured. |



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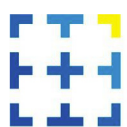


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| 4. Design a storage system using a multi-tiered cache-based approach that leverages investment.                                                                                                    | <p>4.1 Analyse requirements, such as access time, capacity, power consumption, mean time between failure, etc. of the storage system planned.</p> <p>4.2 Analyse market availability and cost of different storage devices and supporting equipment.</p> <p>4.3 Propose a tiered solution that minimises cost and optimises performance.</p> <p>4.4 Evaluate and effectively select the most suitable vendor of required hardware and software systems components.</p> <p>4.5 Prepare appropriate project documentation for a storage systems.</p> |
| 5. Consolidate a data centre hardware infrastructure by virtualisation of redundant systems and better utilise electrical energy; be more robust to individual systems failure and be more secure. | <p>5.1 Analyse the available hardware, operating systems and applications used.</p> <p>5.2 Design a plan of segmentation and isolation of applications assuming that multiple virtual machines and associated operating systems are available.</p> <p>5.3 Select an appropriate virtualisation systems software vendor and version.</p> <p>5.4 Perform a comparative analysis of available virtualisation solutions and present arguments in favour of the choice made.</p>                                                                        |
| 6. Select cloud features and capabilities needed in an enterprise.                                                                                                                                 | <p>6.1 Perform a comparative analysis of cloud systems software products available.</p> <p>6.2 Justify the option selected.</p>                                                                                                                                                                                                                                                                                                                                                                                                                    |
| 7. Build private enterprise cloud infrastructure.                                                                                                                                                  | <p>7.1 Design an appropriate procedure to migrate from a traditional system to a cloud based system.</p> <p>7.2 Design the network, computing and storage hardware infrastructure for a private enterprise cloud system.</p> <p>7.3 Design a procedure for cloud system installation.</p> <p>7.4 Propose a procedure for the migration of an existing data centre infrastructure into the cloud.</p> <p>7.5 Produce project documentation for building a private cloud.</p>                                                                        |
| 8. Implement state-of-the-art cloud application performance monitoring and analytics.                                                                                                              | <p>8.1 Compare and select from currently available cloud administration and cloud performance monitoring solutions.</p> <p>8.2 Produce training documentation and/or multimedia material on how to use cloud performance monitoring utilities.</p>                                                                                                                                                                                                                                                                                                 |





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## Assessment Methodology

| Assessment Criteria Covered  | Assessment Scenario                                                                                                                                                                                                                                                                                                                                          | Assessment Method                                                                                                                                                                                                                                                                                         | Grading Info (optional)                                                                             |
|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 1.1, 1.2, 1.3                | Perform analysis and hardware element inventory in the personal computer of a learner. Use hardware inspection standard system utilities or custom utilities such as CPUZ.<br>Produce a basic executable program in C using basic development tools such as an editor and compiler.                                                                          | Review produced technical report automatically generated by the utilities.<br>Review learner's comments and explanations of meaning of each portion of the automatically generated report<br>Review learner's basic program development procedure taken with screenshots of the work.<br>(Weighted at 7%) | Proper assessment criteria matching learning objectives presented in the report earns 3+4=7 points. |
| 2.1, 2.2, 2.3, 2.4, 2.5      | Perform personal computer operating system analysis of modules available at runtime and available on the storage and not loaded. Produce systems inventory report reading systems registry and using various standard and nonstandard utilities.<br>List all available UI shells. Using help commands and manuals list the 12 most frequently used commands. | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%)                                                                                                                                                                                    | Each matched assessment criteria earns 4+3=7 points                                                 |
| 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 | Explain scheduling of administrative jobs. Present 3 examples of one time and periodic tasks on the learner's system. Compare utilities across Windows and Linux Operating Systems.                                                                                                                                                                          | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%)                                                                                                                                                                                    | Each matched assessment criteria earns 7 points                                                     |
| 4.1, 4.2, 4.3, 4.4, 4.5      | Explain hardware storage devices (Disk, USB-flash, CD/DVD, etc.) used on the learner's personal computer, and produce a report of all parameters of these devices. Use systems firmware (Such as BIOS) and OS utilities (e.g., Windows Control Panel) to                                                                                                     | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%)                                                                                                                                                                                    | Each matched assessment criteria earns 7 points                                                     |



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|                         | produce storage parameter reports.                                                                                                                                                                                                                                                            |                                                                                                                     |                                                                      |
| 5.1, 5.2, 5.3, 5.4      | Study samples of technical papers reporting results of the related work done and producing of the report of the similar mock work done on the hypothetical enterprise.                                                                                                                        | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%) | Each matched assessment criteria earns 7 points                      |
| 6.1, 6.2                | Answer a list of questions regarding cloud computing, private, public and hybrid options.                                                                                                                                                                                                     | Review questions answered and the written report matching portions with the learning objectives. (Weighted at 7%)   | Each matched assessment criteria earns 7 points                      |
| 7.1, 7.2, 7.3, 7.4, 7.5 | Read use case reports or watch the videos describing migration into the cloud. Write a report on the key points to be handled within migration projects. Answer the list of relevant questions.                                                                                               | Review the report and the questions answered matching portions with the learning objectives. (Weighted at 6%)       | Each matched assessment criteria earns 6 points                      |
| 8.1, 8.2                | Setup 30-day free trial accounts with all available public cloud providers, (e.g., AWS, Google, MS Azure). Take screenshots of the provided administrative and performance monitoring GUI utilities.<br>Produce an individual report on each cloud solution and compare all of the solutions. | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%) | Each matched assessment criteria earns 7 points                      |
| Midterm test            | Answer the list of 20 relative questions demonstrating an understanding of the relevant terminology and concepts.                                                                                                                                                                             | Review questions answered. (Weighted at 20%)                                                                        | Each question properly answered earns 1 point, (Max is 20 points)    |
| Final test              | Answer the list of 20 relative questions demonstrating an understanding of the relevant terminology and concepts.                                                                                                                                                                             | Review questions answered. (Weighted at 25%)                                                                        | Each question properly answered earns 1.25 point, (Max is 25 points) |



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## STUDY UNIT 3

### Network Protocols and Network Automation

MQF Level 7

6 ECTS

E-learning: No

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### Rationale

Modern distributed applications demand an intelligent and rapidly adaptable network that is capable of providing application level directory services and optimised connectivity services.

In order to maximise traffic processing network efficiency, it is essential to start with the proper network design, the adequate protocols selection and the least cost - maximal performance equipment capable of using standardised interface protocols with the central network controllers that may rapidly respond to traffic pattern variations and application plane global commands.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Clearly demonstrate conceptual purpose of the computing network as a facility to be used, not to connect computers, for the execution of distributed application programs with modules hosted at the computing nodes that may be physically spread across small or large geographical area;
2. Distinguish between the hardware nature of line signal processing and computation nature of the data link data processing;
3. Evaluate the practical application situation and select an appropriate media/line



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- and media access protocol;
4. Develop an IPv4 addressing plan for a network that has to be connected to the Internet;
  5. Classify distributed applications according to the multimedia message nature and select appropriate transport solutions;
  6. Develop a plan for a router and routing protocol selection and router configuration;
  7. Install and configure a DNS network naming server;
  8. Simulate a simple example of an SDN using Mininet simulator.

## Content – Detailed

1. The introduction to distributed applications explains the basic purpose of a computer network as an executing engine of distributed programs. Division of the standalone (single process) program and use of the Inter Process Communications (IPC) operating system kernel services, as essential for programs distribution, are explained. Distributed applications as multiple process applications passing message data using hardware layer and signals as key network users is explained. Communication line characteristics are also presented.
2. Media access and data link management protocols with relevant algorithms are explained. Media Access Control (MAC) and media use with repeaters, hubs, bridges and switches is discussed. Basic protocol design elements are presented. Standard LAN protocols; 802.3, 802.11, WiFi and Bluetooth 802.15.1 protocols are covered.
3. Standard network layer protocols IPv4 and IPv6 are presented in this topic. Internetworking protocols and routers used to build a network of networks is explained. IPv4 addressing and packet processing with the IPv4 family such as

- DHCP, ICMP, IGMP, ARP and RARP are explained. IP multicast and Anycast, as well as Internet IPv6 protocol packet header structure are also covered.
4. In this topic, transport and application layer message processing protocols are covered. Data types, types of transports, and basic quality of service problems are presented. Error control application to reliable message transport TCP processing is clarified, as well as the fast, seemingly unreliable, UDP transport is explained. In conclusion of this topic, standardised message protocols such as DHCP, HTTP, FTP, SMTP and SNMP are discussed briefly, leaving the more detailed discussions for later units in this programme.
  5. Routing and advanced M\LAN protocols, as well as packet switching with virtual LAN implementation are presented in this lecture. Particular routing protocols, like RIP, OSPF and BGP are discussed with the multimedia message and real time transmission protocols.
  6. Directory services and intelligent network protocols are used to enhance networks and reduce distributed application development. The technology of network directory (information) services is explained in this lecture. Logical network organisation and domain name system service based on the DNS protocol, with standardised directory protocols X,500/X.509, LDAP, and AD protocol are also discussed. The Implementation of cryptographic technology to transform DNS into Secure DNS services (DBNSsec) is covered as well.
  7. Data centre (DC) and cloud system networks using tunnelling protocols in the layers L-2 and L-3 are the focus of this topic. Accelerated network traffic processing, necessary for cloud computing high performance known as multi protocol label switching MPLS and NVGRE are covered. VLAN & VPN (EVPN) security solutions and classical DC transformation to the massively networked and virtualised cloud network system design are presented.
  8. Network device architecture and functions virtualisation (NFV) are the cutting edge technologies used in modern networking system designs. At the core of

such systems are router and switches whose internal architecture is neglected in most of the college level and graduate level networking courses. In order to present application of virtualisation and software defined approaches to modern networking, this lecture analyses these devices and their internal design. Virtual machine, virtual Network Interface Controller (NIC), virtual switch and general approach to network functions virtualisation are explained. Hybrid virtual and real network design are covered as well.

9. Software Define Networks (SDN) design, based on the multi plane-stack software, is the main subject of this topic. Network planes separation and software definition of a network with the SDN north and south bound protocols (OpenFlow, NetConf/Yang, and PCE-P) are analysed. Cloud-based software defined network intelligence with application defined routing imposed upon the lowest planes of the network control architecture are covered.
10. Network orchestration and automation are of utmost importance in modern networks of very high speeds and versatile service capabilities. Network Quality of Service (QoS) combined with the security relevant control is presented. This concluding lecture discusses traffic engineering, network services orchestration and automating network management by centralising network control.

## Assessment Criteria

| Learning Outcomes                                                                                                                                                                                            | Assessment Criteria                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                                                                             | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                     |
| 1. Clearly demonstrate the conceptual purpose of the computing network as a facility used for the execution of distributed application programs hosted by the computing nodes physically spread across small | 1.1 Decide when to use a stand-alone and when to use distributed application architecture.<br>1.2 Evaluate which inter process communication kernel service to use.<br>1.3 Identify application communication protocol modes and types of IPC.<br>1.4 Design a custom application protocol by specifying |



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| or large geographical area.                                                                                                                 | elementary protocol parameters also known as protocol variables.                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 2. Distinguish between the hardware nature of line signal processing and computation nature of the data link data processing.               | 2.1 Classify signals as analogue or digital based on the type of data modulated on a given signal.<br>2.2 Select the appropriate signal modulation for a given communication line.<br>2.3 Evaluate digital line and match its parameters and length with the appropriate line code.<br>2.4 Analyse hardware technical documentation and relate cables to hardware handshaking protocols.                                                                                                                    |
| 3. Evaluate the practical application situation and select an appropriate media/line and media access protocol.                             | 3.1 Identify copper, fibre-optic and wireless-ether lines and compare their spec sheet characteristics.<br>3.2 Evaluate Ethernet LAN and WiFi LAN media access protocols.<br>3.3 Examine project situations where repeaters, bridges and Ethernet switches need to be used.<br>3.4 Define the specifications of the WiFi access point device.<br>3.5 directly link two WiFi devices.<br>3.6 Create a script and schedule a one-time execution of some batch program at the precise time using "at" command. |
| 4. Design IPv4 addressing plan for a network that has to be connected to the Internet.                                                      | 4.1 Distinguish various IPv4 address classes.<br>4.2 Design a plan to use a router and connect a small office LAN to the Internet.<br>4.3 Assign available addresses to each LAN node behind the router.<br>4.4 Design the addressing scheme for the subnet and super-net.                                                                                                                                                                                                                                  |
| 5. Distinguish and classify distributed applications according to the multimedia message nature and select appropriate transport solutions. | 5.1 Distinguish between different multimedia applications based on the used message types.<br>5.2 Classify types of multimedia messages.<br>5.3 Match message type to the transport.<br>5.4 Identify individual transport header fields for TCP and UDP options.<br>5.5 Explain the protocol purpose of each of the transport header fields.<br>5.6 Explain Sliding Window route congestion control protocol and propose a solution on how to handle route delay problems.                                  |





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| 6. Develop a plan for a router and routing protocol selection and router configuration. | 6.1 Identify a router's hardware components.<br>6.2 Identify a router's software components.<br>6.3 Use router IoT UI shell and assign network parameters to the selected hardware interface.<br>6.4 Compare basic routing protocols and identify their intended purpose.                                                                                |
| 7. Install and configure DNS network naming server.                                     | 7.1 Become aware of how a DNS service operates as a distributed infrastructure application and identify individual fields (DNS protocol variables) in the DNS message segment header.<br>7.2 Configure DNS parameters on Windows and Linux network nodes.<br>7.3 Explain the DNS naming scheme.<br>7.4 Compare standard DNS and secure DNSSEC protocols. |
| 8. Simulate a simple example of an SDN using Mininet simulator.                         | 8.1 Design an SDN controlled network using management planes.<br>8.2 Explain the purpose and functionality of the northbound and southbound SDN protocols.<br>8.3 Identify all bare switch components and flow table structure.<br>8.4 Analyse the SDN controller architecture.                                                                          |

## Assessment Methodology

| Assessment Criteria Covered | Assessment Scenario                                                                                                                                                                                                                                                                                                                                                                                                                              | Assessment Method                                                                                                                                                                   | Grading Info (optional)                                   |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| 1.1, 1.2, 1.3, 1.4          | Perform command shell use of pipelined filter utility programs and explain kernel pipe IPS service and its inability to be applied onto a network. Explain protocol organisation in time sequenced starting and work performed asymmetry. Identify popular distributed applications (FTP, TELNET, WEB), explain their use, and basic protocol key words. Demonstrate distributed application configuration using FTP example command line shell. | Review of the learners work results and documented report with screenshots. Review learner's comments and explanations of meaning of each portion of their report. (Weighted at 7%) | Proper assessment criteria report earns 2+2+2+1=7 points. |
| 2.1, 2.2, 2.3, 2.4          | Using a given data bit sequence, perform paper line modulation of                                                                                                                                                                                                                                                                                                                                                                                | Review of the written document and matching                                                                                                                                         | Each matched assessment                                   |



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|                              | digital signals using minimum three line codes (NRZ, AMI and Manchester codes).<br>Design an analogue modulation scheme for the given digital NRZ signal to maximise analogue line throughput using QAM.<br>Evaluate line quality by inspection of the eye diagram.<br>Design QAM phase plane following the requirements.                                                                          | portions of the document with the learning objectives.<br>(Weighted at 7%)                                             | criteria earns $2+2+1+2=7$ points                         |
| 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 | Identify and explain characteristics of the base band twisted pair copper lines and coaxial band-pass lines.<br>Identify and explain characteristics of the WiFi ether lines.<br>Explain Ethernet CMA/CD and WiFi media access protocols and explain Ethernet synchronisation as well as addressing scheme.<br>Use a suitable utility to inspect Ethernet and WiFi parameters on the learner's PC. | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%) | Each matched assessment criteria earns $2+2+2+1=7$ points |
| 4.1, 4.2, 4.3, 4.4           | Design an addressing scheme for a subnet.<br>Design an addressing scheme for a super-net.                                                                                                                                                                                                                                                                                                          | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%) | Each matched assessment criteria earns $1+2+2+2=7$ points |
| 5.1, 5.2, 5.3, 5.4, 5.5, 5.6 | Identify analogue data formats and file extensions for three audio and three video data types.<br>Identify a minimum of three digital data types and file formats.<br>Start digital data large file download, then audio and video streaming (Local play). Use proper network traffic monitoring utilities to inspect the port numbers and transport types used in each of the cases.              | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 6%) | Each matched assessment criteria earns $2+2+2=6$ points   |
| 6.1, 6.2, 6.3, 6.4           | Explain three different situations where different routing protocols have to be used.<br>Use a network simulator such as packet tracer, simulate a small internetwork using three routers, log                                                                                                                                                                                                     | Review questions answered and the written report matching portions with the learning objectives.<br>(Weighted at 7%)   | Each matched assessment criteria earns $2+5=7$ points     |





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|                    | into each router and using console commands perform basic router interface configuration.                                                                                                                                                                      |                                                                                                                        |                                                                          |
| 7.1, 7.2, 7.3, 7.4 | Explain each field in the DNS segment header.<br>Install BIND DNS server software and configure minimal name translation table.<br>Explain how DNSSEC protects against cyber attacks.                                                                          | Review the report and the questions answered matching portions with the learning objectives.<br>(Weighted at 7%)       | Each matched assessment criteria earns 2+3+2= 7 points                   |
| 8.1, 8.2, 8.3, 8.4 | Install a virtual machine and Mininet simulator. Simulate a small SDN controlled network.<br>Install Wireshark traffic monitoring software and attach it to the simulated SDN controller ports, Prepare a report of traffic monitoring in different scenarios. | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%) | Each matched assessment criteria earns 2+5=7 points                      |
| Midterm test       | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts.                                                                                                                                                          | Review questions answered.<br>(Weighted at 20%)                                                                        | Each question properly answered earns 1 point, (Maximum is 20 points)    |
| Final test         | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts.                                                                                                                                                          | Review questions answered.<br>(Weighted at 25%)                                                                        | Each question properly answered earns 1.25 point, (Maximum is 25 points) |



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## STUDY UNIT 4

### Data Science and Predictive Analysis

MQF Level 7

6 ECTS

E-learning: No

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### Rationale

Employing a practical approach to database systems design, implementation and use to support modern applications, requires thorough understanding of internal database engine operation. Integrating a variety of data sources is essential for decision support analytic systems design and business intelligence applications. To appreciate the power of data science and predictive analytics, a hands-on experience is of essence. The most average learner friendly data science path helping learners gain predictive analytics skills is to use R programming language console.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Differentiate between the information, data, data types and data-codes.  
Recognise the importance of the business side of data processing and algorithms built in modern information management systems;
2. Demonstrate practical skills of how to install practical RDBMS server, how to use SQL command line client shell program, configure client and server modules, and test TCP/IP connectivity using networking and OS administrative utility programs;

3. Design sample application queries that are protected against accidental power or connection loss using transaction management system and relevant transaction processing SQL queries;
4. Perform practical enterprise use case, object oriented (OO) and RDB analysis, ER modelling to design a DB schema;
5. Use RDBMS built-in functions, create stored procedures and integrate RDBMS programs and RDB stored programs with application layer code;
6. Identify data that can be organised in a table or up-side-down tree and select proper data description language and DBMS software;
7. Design and install analytical heavily indexed RDB and design and implement NoSQL database;
8. Design, install and use R-shell as a tool to perform data cleansing, algorithmic data analysis and user-friendly result charting.

## Content – Detailed

1. Data, codes, and structured record management are core topics of this introductory lesson. Distinction between data with codes and information within a decision making process are essential for further study and practice of analytic and big data processing. Historical overview of the origins of modern business data processing and the overview of data organisation with the Create, Read, Update and Delete (CRUD) mandatory operations are covered. Analysis of index algorithms for acceleration of the large data sets use and individual record access are presented. Table and tree based databases are covered.
2. Relational algebra and relational database query processing are main topics of this lecture. Real world enterprise analysis, entity and relationships (ER) identification modelling using ER diagrams, and ER diagrams comparison to OO analysis UML diagrams is performed. Relational algebra is introduced in

order to understand the theoretical concepts behind query language design. Furthermore learners will be exposed to database schema as the method of database design and preparation for database implementation.

3. Structured Query Language (SQL) as a 4GL standardised query language of relational databases is introduced in a practical manner on the example of the MySQL as a sample of the RDBMS. The practical procedure of MySQL RDBMS installation and configuration is presented. Using SQL shell and SQL-DDL queries to create database and DB objects, as well as data manipulation using SQL-DML are covered. Security and maintenance operations using SQL-DCL skills are highlighted at the end of this lecture.
4. Reliable transaction management RDBMS module is what transforms the record manager into a database management system. This fact is stressed in this topic as a method of introducing RDBMS internal core system architecture. Transaction management mandatory attributes of Atomicity, Consistency, Isolation and Durability (ACID) as fundamental for implementation of the distributed database implementation are explained. Transaction management protocols known as 2PC and 3PC are explained as well. Practical transaction control using relevant SQL commands is demonstrated.
5. The procedure to design and implement a relational database (RDB) is introduced in this topic. Also explained is how RDB design binds the real world use case analysis or ER modelling results, with the Object Oriented (OO) application programs which are typically developed using UML models. Practical analysis and DB schema design using DBA software CASE tools is demonstrated. Data Recovery (DR) measures, DB storage and backup design with DB migration procedures (DB export and import), are also shown.
6. RDB and application integration is the final goal of all DB design efforts. Using built-in RDBMS functions to minimise application programming time is demonstrated through the MySQL sample of the RDBMS. Creating and sharing

triggers and stored procedures as an additional method of reducing application level programming effort is also demonstrated. Integrating application code (PHP and JavaScript) and RDBMS practical examples are presented. Database user profiles and roles creation as security administration activities are demonstrated. Security issues related to the SQL injection problems are explained. Developing an example application and RDBMS integration with the Web server is also demonstrated.

7. This topic deals with the unstructured, meaning non-table based data management. The concept of a document is explained. Document description languages (HTML, XML, JSON) and processing engines are introduced. Standard XML languages (DTD, XSLT, XPATH, SQLX/XSQL), their purpose and use are explained. Not Only SQL (NoSQL) databases such as MongoDB are presented.
8. Being pertinent topics, big data systems management and data analytics are covered in this unit. Data mining, data warehousing and Business Intelligence (BI) are explained. The practical concept of big data is demonstrated on the Apache Hadoop as an example.
9. Predictive analytics is introduced using practical examples in R language. Installation of R and R-system shells, and R-shell interaction techniques are presented. An overview of R shell commands and methods of handling data from diverse data sources are demonstrated in a practical manner. The important activity in predictive data analytics, known as data cleansing, is explained. Practical use of R packages for statistical data analysis and graphical data presentation is demonstrated. This topic is concluded with the application of R Python in machine learning and artificial intelligence relevant problem solving.
10. The presentation of data using graphs and charts data is important as an activity that supports management decision-making. Decision Support Systems

(DSS), business intelligence and power of graphics using R packages to visually present data is demonstrated using practical examples. The use of Scalable Vector Graphics (SVG) to produce flexible graphical data presentation in the browser's window is demonstrated. Browser powered scalable graphics using JavaScript graphics libraries (3D, Google Charts) are demonstrated. The use of Microsoft Office for visual data presentation could not be neglected and is covered here as an extension to the material presented in the first unit on the MIS problems.

## Assessment Criteria

| Learning Outcomes                                                                                                                                                                                                                                      | Assessment Criteria                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                                                                                                                       | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                                                                                                  |
| 1. Differentiate between the information, data, data types and data-codes. Recognise importance of the business side of data processing and algorithms built in the modern information management systems.                                             | 1.1 Recognise the importance of storage media and data codes.<br>1.2 Match data types and properties of the storage media to the data code.<br>1.3 Value efficient algorithms in applications that require rapid stored data access.<br>1.4 Compare SAM, ISAM, bSTAM, BTAM and B+TAM data access methods.<br>1.5 Identify data records and mandatory CRUD operations on data records. |
| 2. Demonstrate practical skills of how to install practical RDBMS server, how to use SQL command line client shell program, configure client and server modules, and test TCP/IP connectivity using networking and OS administrative utility programs. | 2.1 Perform the custom installation, configuration and testing of the RDBMS server and command line SQL shell.<br>2.2 Perform basic administrative SQL-DDL commands, create and delete database objects.<br>2.3 Import database design and data.<br>2.4 Manipulate data using SQL-DML.<br>2.5 Use basic SQL-DCL commands.                                                             |



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| 3. Design sample application queries that are protected against accidental power or connection loss using transaction management system and relevant transaction processing SQL queries. | <p>3.1 Explain the concept of data integrity.</p> <p>3.2 Design a concurrent data access method with a strategic approach to deadlock prevention and avoidance.</p> <p>3.3 Explain the ACID principles of a trusted transaction manager.</p> <p>3.4 Distinguish between different transaction management algorithms.</p> <p>3.5 Implement transactions using SQL commands using given application data.</p> |
| 4. Perform practical enterprise use case, object oriented (OO) and RDB analysis, ER modelling to design a DB schema.                                                                     | <p>4.1 Perform ER modelling and produce model report.</p> <p>4.2 Use the DBA productivity GUI.</p> <p>4.3 Use UML drawing ClickCharts tool and produce UML modelling of the same enterprise modelled using ER diagrams.</p> <p>4.4 Compare UML classes to ER entities, ER relationships to class properties and attributes.</p>                                                                             |
| 5. Use RDBMS built-in functions, create stored procedures and integrate RDBMS programs and RDB stored programs with application layer code.                                              | <p>5.1 Use built-in RDBMS function library in SQL queries.</p> <p>5.2 Program table action tracking using triggers.</p> <p>5.3 Write and store procedure using 3GL and SQL combined.</p> <p>5.4 Connect user layer application programs to the RDB and access stored programs.</p>                                                                                                                          |
| 6. Identify data that can be organised in a table or up-side-down tree and select proper data description language and DBMS software.                                                    | <p>6.1 Distinguish hierarchical document from relational data.</p> <p>6.2 Explain hierarchical data using XML and JSON.</p> <p>6.3 Transform XML into HTML and render data using browser.</p> <p>6.4 Design and implement a NoSQL database.</p>                                                                                                                                                             |
| 7. Design and install analytical heavily indexed RDB and design and implement NoSQL database.                                                                                            | <p>7.1 Design and implement a data warehouse database.</p> <p>7.2 Import and consolidate data of various formats into to the warehouse.</p> <p>7.3 Analyse data using SQL and MS Excel graphical presentation features.</p> <p>7.4 Design and document the design of the big data system.</p>                                                                                                               |
| 8. Design, install and use R-shell as a tool to perform data cleansing, algorithmic data analysis and user-friendly result charting.                                                     | <p>8.1 Plan the implementation of the oversized database using off-the-shelf standard computers and storage devices.</p> <p>8.2 Install the R programming shell.</p> <p>8.3 Import data from dissimilar data sources, cleansing data using R to remove bad records or impute missing field values.</p> <p>8.4 Use R to generate browser powered charting report.</p>                                        |



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## Assessment Methodology

| Assessment Criteria Covered | Assessment Scenario                                                                                                                                                                                                                                                                                                                                                                                                                                | Assessment Method                                                                                                                                                                    | Grading Info (optional)                                   |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| 1.1, 1.2, 1.3, 1.4          | Use Google search engine to perform market analysis on history, current trends and profitability data processing.<br>Itemise a list of data types, and respective codes used in application compilers and data management systems. Observe the difference in codes and problems when integrating application code to DBMS.<br>Evaluate and present pros and cons of use of different data access algorithms.<br>Identify core modules in the DBMS. | Review of the learner's work results and documented report with screenshots. Review learner's comments and explanations of meaning of each portion of their report. (Weighted at 7%) | Proper assessment criteria report earns 2+2+2+1=7 points. |
| 2.1, 2.2, 2.3, 2.4          | Explain mapping of the RW to the CW, and purpose of analysis process.<br>Itemise DB development phases. Perform a sample use case analysis and present ER entity based and UML class based enterprise models, using CAD ER/UML modelling tools. Design and specify DB scheme.                                                                                                                                                                      | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)                                                                  | Each matched assessment criteria earns 1+2+2+2=7 points   |
| 3.1, 3.2, 3.3, 3.4, 3.5     | Install RDBMS server and SQL shell client and test connectivity. Perform SQL DCL, DDL, and DML queries.<br>Use relational algebra to design complex SQL query involving joins. Install Web server, configure port numbers, and test connectivity with the front-end browser and DBMS server on the back end.                                                                                                                                       | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)                                                                  | Each matched assessment criteria earns 1+2+2+2=7 points   |
| 4.1, 4.2, 4.3, 4.4, 4.5     | Compare design situations using different methods for transaction control. Compare transaction control performed by the OS on the file level                                                                                                                                                                                                                                                                                                       | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)                                                                  | Each matched assessment criteria earns 2+1+2+2=7 points   |





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|                    | <p>and RDBMS on the record level and their complementary value.</p> <p>Explain the deadlock mechanism and propose methods on how to prevent the deadlock of parallel transactions.</p> <p>Perform and execute a transaction using SQL batch of queries.</p>                                                                                                                                                                                                                                                            |                                                                                                                            |                                                                  |
| 5.1, 5.2, 5.3, 5.4 | <p>List all sample RDBMS (MySQL) built-in functions and explain their joint purpose.</p> <p>Execute various SQL queries using DBMS functions to manipulate date, text strings, structure report tables, and perform basic statistical analysis operations.</p> <p>Use 3GL and SQL to write stored procedure and triggers associated with selected table activities.</p> <p>Write and connect a simple PHP program behind the Web server to RDBMS, perform query and pass the report as a HTML page to the browser.</p> | <p>Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)</p> | <p>Each matched assessment criteria earns 1+1+2+3=7 points</p>   |
| 6.1, 6.2, 6.3, 6.4 | <p>Create a tree model of the given HTML, XML and JSON sample documents.</p> <p>Map the tree model to the container model.</p> <p>Demonstrate the document transformation procedure.</p> <p>Use XSLT to transform an XML document to HTML.</p> <p>Install MongoDB, create NoSQL database and store document.</p>                                                                                                                                                                                                       | <p>Review of the written document and matching portions of the document with the learning objectives. (Weighted at 5%)</p> | <p>Each matched assessment criteria earns 1+1+1+2+2=7 points</p> |
| 7.1, 7.2, 7.3, 7.4 | <p>Design a simple data warehouse DB.</p> <p>Import MS Excel and CSV data into the warehouse DB.</p> <p>Design a complex analytic query, capture and export the report to MS Excel and generate a user-friendly graphical DSS management report.</p> <p>Explain the attributes of big data systems architecture and access methods.</p>                                                                                                                                                                                | <p>Review questions answered and the written report matching portions with the learning objectives. (Weighted at 7%)</p>   | <p>Each matched assessment criteria earns 2+1+2+2+=7 points</p>  |



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| 8.1, 8.2, 8.3, 8.4 | <p>Install R analytic shell.</p> <p>Demonstrate OS shell access from the R shell, manipulate files manipulate directories, and manipulate R data objects.</p> <p>Import MS Excel, XML and RDB (from MySQL) data into the R shell data objects.</p> <p>Perform statistical analysis on the imported data and generate a graphical DSS report.</p> | Review the report and the questions answered matching portions with the learning objectives. (Weighted at 6%)       | Each matched assessment criteria earns 1+1+2+2=6 points               |
| Project            | <p>Perform all database design steps on the given enterprise.</p> <p>Design an application using PHP on XAMP/WAMP.</p> <p>Populate the DB with data and execute application level queries using browser forms and reports.</p> <p>Use JavaScript to transform the report data into a Web chart.</p>                                              | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%) | Each matched assessment criteria earns 1+1+1+2= 5 points              |
| Midterm test       | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts.                                                                                                                                                                                                                                            | Review questions answered. (Weighted at 20%)                                                                        | Each question properly answered earns 1 point, (Maximum is 20 points) |
| Final test         | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts.                                                                                                                                                                                                                                            | Review questions answered. (Weighted at 20%)                                                                        | Each question properly answered earns 1 point, (Maximum is 20 points) |



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## STUDY UNIT 5

### Foundations of Cyber Security

MQF Level 7

6 ECTS

E-learning: No

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### Rationale

This unit presents fundamental concepts of cyber security relevant to all systems levels, starting with the systems and device firmware, covering systems memory, storage devices, file systems, network traffic processing devices (e.g., network switches, routers and firewalls), as well as user application programs.

This study unit demonstrates management of the operating systems security, distributed application such as RDBMS server security and network security.

For safer business and society, at all systems levels it is of the essence to maintain high security resilience.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Recognise the vulnerabilities present in hardware systems as well as software systems, and acquire skills to access a system's firmware using special hardware UI shells or OS utility programs;
2. Install and use relevant program development tools when developing an application program recognising all development phases leading up to the runtime;



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3. Gain awareness of program's external and internal visibility at runtime, while being able to use the proper utilities to focus on program internal activities that may lead to the unexpected termination or undesirable performance;
4. Protect a system's memory and file system from unauthorised programs and illegal uses;
5. Apply knowledge of crypto technologies to externally protect applications and operating systems;
6. Configure system front doors and network data traffic processing nodes and apply cryptography to create safe network tunnel paths;
7. Implement system and network activity monitoring facilities and protect security logs;
8. Distinguish between intrusion and extrusion attacks and scheduled from continuous backups mechanisms.

## Content – Detailed

1. As the initial point in the security chain, the systems firmware security protection requirement is presented in this lecture. Hardware platform basics presented in the second unit is further explained in this lecture. Practical examples of the organisation of the systems firmware such as BIOS and OpenBoot with the pre-boot systems security issues are presented stressing systems firmware shells use and hardware parameters meaning. Modern pre-boot solutions such as EFI/UEFI and relevant security issues are also covered.
2. Protection of the software systems start at the program development phase. This lecture elaborates on the early possibilities of software infection at compile time. The software engineering practice of reusing third party software is discussed from the security point of view. Practical examples of program lifetime evolution phases using C programming language demonstrate the reuse of source, as well as the object code that could be infected with the

- malicious viral code. Practical examples of procedures of source code pre-processing and static linking are analysed.
3. Modern programs – written using third generation languages (3GL) and vulnerability at runtime is the main topic of this lecture. The instruction execution sequence behaviour at run time is analysed. Run time stack frames protection options are presented. Examples of dynamic variables misuse and input buffer overflow attacks are presented. Stack smashing attacks and appropriate defences are presented too.
  4. Operating system memory protection is an elementary issue to deal with within the overall strategy of protecting programs in execution. The address processing unit (AU) built-in as a standard module of modern central processors, the operation of the Virtual Memory Management Unit (VMMU introduced in the second unit of this programme) and the use of the dynamic address translation table (DATT) in controlling access of memory are discussed from the security point of view. In addition to the memory management related security file system, security and file access control is discussed also. Practical examples of the file system functional organisation such as FAT, NTFS, UFS, and ext2 are presented. File access control methods are also covered.
  5. Fundamental concepts of crypto technologies, hashing algorithms, digital signature and digital certificate are explained. These are important to know in systems administration practice, as well as for understanding cryptocurrencies (covered in one of the following units). Symmetric cryptography, one-way hashing, and asymmetric cryptography used in the implementation of the X.509 standard digital certificate is discussed. Single sign-on (SSO) and Kerberos technology application to enterprise security is covered too.
  6. Role Base Access Control (RBAC) and Identity Management (IM) are the main topics of this lecture. Discretionary and capability-based access control are compared, highlighting the pros and cons, looking at one or the other or the

hybrid mix of the two. Enterprise systems administration with tens or hundreds of highly privileged users is discussed. Flexible groups and rules with RBAC and restricted shells, as well as identity management are covered.

7. Systems and network access control technical solutions are presented in this lecture. User and identity concepts are explained from the technical point of view. Front door systems shells and the phenomena of the back-door attacks as well as rootkit attacks are covered. Within a network security framework, the use of firewalls (static and dynamic) for network access control and crypto technologies application to Virtual Private Networking (VPNs) and IPsec protocol are presented.
8. Systems and network device activity monitoring is considered a standard and good security relevant practice that is discussed in this lecture. Practical examples of systems activities monitoring, known as syslog facility and syslog protocol, are discussed too. System auditing procedures and software tools used in Windows and Linux operating systems are covered. Network access control design with Cisco's AAA solutions, as well as the design of in-band and out-of-band monitoring systems are presented.
9. Intrusion detection systems (IDS) such as anti-virus programs and network traffic monitoring are subjects of this lecture. Ethical hacking practice in verifying and validating existing security solutions is explained. System and network intrusion and extrusion examples are presented. Black hat zero-day hacking exploits and attack vectors are compared with the white hacker and ethical hacking practice and procedures.
10. Backup and disaster recovery (DR) introduced in the first study unit of the programme is further explained here. Standard small system backup procedures and continuous backup detailed solutions are presented. DR procedures and basic principles of forensics are covered too.



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## Assessment Criteria

| Learning Outcomes                                                                                                                                                                                                            | Assessment Criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                                                                                             | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 1. Recognise the vulnerabilities present in hardware systems as well as software systems and acquire skills to access systems firmware using special hardware UI shells or OS utility programs.                              | 1.1 Perform systems hardware configuration using the UI menu shell or command line shell.<br>1.2 Configure two levels of systems firmware protection at the hardware, as well as OS level.<br>1.3 Define each of the configurable systems hardware parameters.<br>1.4 Perform damaged hardware configuration recovery.<br>1.5 Explain POST and boot strap procedures.                                                                                                                          |
| 2. Install and use relevant program development tools when developing an application program recognising all development phases leading up to the runtime.                                                                   | 2.1 Install a custom source code editor, source pre-processor, compiler, linker and integrated development environment (IDE).<br>2.2 Perform all program development steps on the given sample program and examine the output of each of the program development tools.<br>2.3 Perform IDE configuration and recognise shell environment support via relevant shell variables.<br>2.4 Determine the path of programming language and software engineering evolution.                           |
| 3. Gain awareness of program external and internal visibility at runtime, while being able to use proper utilities to focus on program internal activities that may lead to unexpected termination or unplanned performance. | 3.1 Track program thread evolution in process including branches out of code segment into the kernel service routine and return.<br>3.2 Track program dynamic variables, and runtime stack in the heap space.<br>3.3 Explain the buffer overflow and stack smashing attacks.<br>3.4 Propose programming internal defences and propose use of external host based firewall as a systems defence mechanisms, (e.g., demonstrate the use of such as antivirus and jail programs).                 |
| 4. Gain skills and tools knowledge needed to protect systems memory and file system from unauthorised programs and their illegal users.                                                                                      | 4.1 Inspect systems virtual memory and explain memory protection through DATT based memory space segmentation and isolation.<br>4.2 Configure user accounts on Windows and Linux OS and relate accounts to the file system.<br>4.3 Control default access and customise file access.<br>4.4 Distinguish characteristics of different file systems structure.<br>4.5 Use proper tools to create file system of choice.<br>4.6 Classify security levels and different methods of access control. |



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| 5. Apply practical knowledge of crypto technologies to externally protect applications and operating systems.                         | <p>5.1 Discuss the pros and cons of symmetric and asymmetric cryptographic solutions and their complementary hybrid use in PKI.</p> <p>5.2 Understand password protection and cracking methods.</p> <p>5.3 Apply hashing algorithms and asymmetric cryptography to create a digital signature.</p> <p>5.4 Create a digital certificate and interpret each field in the certificate using X.509 standard.</p> <p>5.5 Design a digital certification server network.</p> |
| 6. Configure system front doors and network data traffic processing nodes and apply cryptography to create safe network tunnel paths. | <p>6.1 Manage and protect user identity.</p> <p>6.2 Configure password aging and other front door shell parameters on Windows and Linux systems.</p> <p>6.3 Analyse the dynamics of various levels of firewall and security gateway operation.</p> <p>6.4 Use IoS UI shell to perform basic firewall configuration commands.</p> <p>6.5 Design SSL based VPN gateway based secure tunnel.</p>                                                                          |
| 7. Implement system and network activity monitoring facilities and protect security logs.                                             | <p>7.1 Understand the principles of monitoring and logging.</p> <p>7.2 Configure, enable and disable systems logging facility.</p> <p>7.3 Configure the router monitoring system using IoS UI shell commands.</p> <p>7.4 Design a distributed systems logging system.</p>                                                                                                                                                                                              |
| 8. Distinguish intrusion from extrusion attacks and scheduled from continuous backups mechanisms.                                     | <p>8.1 Design an out-of-band security meta network and relevant intrusion detection data collection.</p> <p>8.2 Establish promiscuous network traffic collection and analysis.</p> <p>8.3 Perform penetration testing and ethical hacking procedures.</p> <p>8.4 Propose disaster recovery policy and procedures.</p>                                                                                                                                                  |

## Assessment Methodology

| Assessment Criteria Covered | Assessment Scenario                                                                                                                                                                                                                                                                                                                   | Assessment Method                                                                                                                                                | Grading Info (optional)                                          |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| 1.1, 1.2, 1.3, 1.4, 1.5     | <p>Learner should start hardware system POST, stop and document systems banner report, explaining the meaning of each reported parameter.</p> <p>Enter the systems firmware UI shell on the WinTel PC or Mac and describe six different hardware parameter purpose and optional values.</p> <p>Demonstrate firmware shell use and</p> | <p>Review of the learner's work results and documented report with screenshots.</p> <p>Review learner's explanations of conceptual elements presented in the</p> | <p>Proper assessment criteria report earns 2+2+2+1=7 points.</p> |



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|                                        | parameter adjustment.<br>Recover system by loading preset default hardware configuration values.                                                                                                                                                                                                                                                                                    | learner's report.<br>(Weighted at 7%)                                                                                  |                                                            |
| 2.1, 2.2, 2.3, 2.4                     | Install C/C++ programming integrated development environment (IDE) and configure key parameters.<br>Explain the difference between reprogramming and reconfiguration.<br>Edit, compile, link and test-run a simple C program demonstrating function calls and returns.<br>Explain stack use at runtime to support modular software design at compile time.                          | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%) | Each matched assessment criteria earns 2+2+2+1=7 points    |
| 3.1, 3.2, 3.3, 3.4                     | Use default system utilities to monitor running program parameters.<br>Install and use powerful external utilities for running program inspection.<br>Inspect program's stack trace.<br>Explain the purpose of and method of how to protect buffers as dynamic I/O variables exposing programs to attacks.<br>Explain the basic functionality of an antivirus.                      | Review of the written document and match portions with the learning objectives.<br>(Weighted at 7%)                    | Each matched assessment criteria earns 2+1+2+1+1=7 points  |
| 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 6.1, 6.2 | List and explain all front door shell parameters.<br>Customise login shell parameters to better protect system.<br>Inspect default file access control parameters and customise each parameter using proper utility.<br>Individualise file access permissions.<br>Classify file access methods.<br>List security classification levels.                                             | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%) | Each matched assessment criteria earns 1+2+1+2+1=7 points  |
| 5.1, 5.2, 5.3, 5.4, 5.5                | List symmetrical encryption algorithms and isolate the strongest.<br>Identify symmetric encryption main problems and solutions.<br>Explain asymmetric cryptography use to prove message source identity with digital signature.<br>Explain replay and man-in-the-middle attacks and the need for the third party protection mechanism.<br>Create and demonstrate use of the digital | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%) | Each matched assessment criteria earns 1+1+1+1+3= 7 points |





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|                    | certificate.                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                               |                                                                   |
| 6.3, 6.4, 6.5      | Explain router NAT function use to hide internal network node address.<br>List possible firewall traffic filtering options and match each to the particular practical network perimeter protection scenario.<br>Use Cisco packet tracer or equivalent network simulator, login into router's IOS, and use shell commands to configure interface ports and NAT parameters.<br>Document design of the SSL gateway server use to implement VPN secure tunnel. | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)                           | Each matched assessment criteria earns 1+1+3+2=7 points           |
| 7.1, 7.2, 7.3, 7.4 | Configure syslog facility on Linux system.<br>Inspect event monitoring Windows function and explain its report parameters.<br>Using a simulated network, log into router's shell and configure syslog parameters.<br>Select components and design intrusion detection traffic collection meta network.                                                                                                                                                     | Review questions answered and the written report matching portions with the learning objectives. (Weighted at 7%)                             | Each matched assessment criteria earns 1+1+1+4=7 points           |
| 8.1, 8.2, 8.3, 8.4 | Use proper Linux utilities to perform system auditing.<br>Explain a small system scheduled multi tape backup procedures.<br>Perform sample disaster recovery scenario using tape backups.                                                                                                                                                                                                                                                                  | Review questions answered and the written report matching portions with the learning objectives. (Weighted at 6%)                             | Each matched assessment criteria earns 2+2+2=6 points             |
| Project            | Install Kali Linux, select three intrusion problems of your choice, demonstrate and document use of this suit of security tools.                                                                                                                                                                                                                                                                                                                           | Review of the written project report document and matching portions of the document with the learning assignment objectives. (Weighted at 5%) | Each matched assessment criteria earns 5 points                   |
| Midterm test       | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts.                                                                                                                                                                                                                                                                                                                                                      | Review questions answered and matching portions of the document with the learning objectives. (Weighted at 20%)                               | Each question properly answered earns 1 point, (Max is 20 points) |



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|            |                                                                                                       |                                                                                                                 |                                                                  |
|------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| Final test | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts. | Review questions answered and matching portions of the document with the learning objectives. (Weighted at 20%) | Each question properly answered earns 1 point (Max is 20 points) |
|------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|



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## STUDY UNIT 6

### Web Technologies and Secure E-Commerce

MQF Level 7

6 ECTS

E-learning: Yes

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### Rationale

E-commerce is expanding at an astonishing rate, offering communities far from the metropolitan areas to acquire and trade goods in the borderless and distance oblivious cyberspace. This unit provides a structured foundation of Web technologies necessary to technically implement e-commerce websites or maintain existing e-commerce operations. Vocational specific details are delegated to the vast public computer-based training (CBT) and courseware material that is easy to follow.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Conceptualise distributed application development simplification by isolating reusable message exchange protocol software and reinforce this development strategy for the implementation of the HTTP protocol;
2. Apply markup languages such as HTML, XML and SVG-XML to control rendered document appearance in the browser's window;
3. Explain browser and Web server framework architecture and show how to benefit from this well-standardised client/server reusable design and framework by applying the extension software engineering principle;
4. Program interactive Web applications using JavaScript 3GL;



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5. Develop light, interactive and RESTful Web services based on server side application program using PHP and/or JavaScript;
6. Utilise open source programs to rapidly implement PKI security infrastructure in the e-commerce Web site design;
7. Implement e-commerce PCI compliant payment processing system;
8. Conceptualise a cost effective digital marketing strategy and implement a marketing plan.

## Content – Detailed

1. As the core of the Web building block, Hyper Text Transport Protocol (HTTP) messaging protocol is covered in this lecture. The common engineering art principle applied to distributed software engineering of layering protocols is demonstrated using the HTTP protocol. Web server architecture, and HTTP traffic caching applied to the Web performance and security improvement are presented using the open-source Apache solution. Communicating with the HTTP protocol using very high-level meta tags in the Hyper Text Mark-up Language (HTML) is demonstrated. Secure HTTP options, such as SHTTP and HTTPS are distinguished.
2. Document description languages such as: HTML, XML, and SVG are presented in this lecture. HTML versions 3, 4 and 5 and HTML blended with XML are described. The Scalable Vector Graphics (SVG) version of XML applied to modern browser rendering graphics technology is also explained.
3. Browser internals and built-in object programmability within a Web browser architecture are explained. Web browser built in default objects and the HTML standard tags are related. Web browser extensions and plugin procedures are covered. Web browser configuration parameters commonly found in browsers such as Google Chrome, Firefox, MS Internet Explorer are discussed as well,

paying particular attention to security related browser's configuration parameters.

4. Browser rendering data documents using HTML, the use of Cascaded Style Sheet (CSS), JavaScript, and XSLT are explained in developing front-end Web applications. CSS is presented as a display control language, JavaScript as a 3GL Web objects control language, and XML as hierarchical data description language. XML Stylesheet Language Transformations (XSLT) are also covered.
5. Web server architecture, installation and administration procedures, and the development of the back-end portion of the Web application are topics of this lecture. An example of the Apache Web server is demonstrated and modern back-end JavaScript solutions such as NodeJS are discussed. NodeJS installation and JavaScript server-side scripting are demonstrated. The use of Web server data source and back-end application integration with the RDBMS NoSQL DBMS and Web Services are covered too.
6. Concepts of XML-based Web services, Simple Object Access Protocol (SOAP) solution, and JavaScript Object Notation JSON RESTful services architectures are discussed in this lecture. Web service based distributed architecture of the SOAP based applications and RESTful services based architectures are compared. Building and using REST APIs is also discussed.
7. Public Key Infrastructure (PKI) and digital certificate application to securing e-commerce Web portals and transactions are main topics of this lecture. E-commerce infrastructure design principles are introduced. Practical digital certificate generation and processing are demonstrated. PKI system design and implementation is presented. Enveloped Public Key Encryption (EPKE), as well as the weakness and computational costs involved are explained.
8. The Payment Card Industry (PCI) standard and payment processing services are analysed and modelled. The e-commerce business model, business process, and the design of the e-commerce system are presented. Use of the

UML (introduced in the first unit) to model sensitive mechanisms of the digital payment processing system to fulfil the PCI compliance is demonstrated.

9. Web commerce promotion and e-marketing are presented in this lecture. Digital marketing plan, digital marketing technical and strategic methods and Web based mechanisms are discussed. Social media as a marketing platform is presented. Digital marketing efforts tracking and effectiveness evaluation, i.e., performance measurement are also described.
10. Future of the Web, such as Web 2.0 and Web 3.0 are discussed. History of Web generations, starting with the static and dynamic Web generations leading to the intelligent and secure Web are presented. Major contributors to the Web development are identified. Besides e-commerce, Web powered solutions such as e-education, e-health, e-government, e-logistics (presented in the first unit), and e-governance as new business models are presented taking into account the massive use of the hand-held networked mobile computing devices with high multimedia capabilities.

## Assessment Criteria

| Learning Outcomes                                                                                                                                                                                                 | Assessment Criteria                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                                                                                  | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                                                                                                                                                                         |
| 1. Conceptualise distributed application development simplification by isolating reusable message exchange protocol software and reinforce this development strategy for the implementation of the HTTP protocol. | <ol style="list-style-type: none"> <li>1.1 Design a layered distributed application isolating message protocol.</li> <li>1.2 Apply the concept of the message protocol by using lightweight HTTP protocol key word set.</li> <li>1.3 Explain the purpose of all HTTP command and status key words.</li> <li>1.4 Demonstrate security related HTTP gateway message exchange.</li> <li>1.5 Explain the SSL based conversion of HTTP into the HTTPS.</li> </ol> |
| 2. Apply markup languages such as HTML, XML and SVG-XML to                                                                                                                                                        | <ol style="list-style-type: none"> <li>2.1 Use HTML meta tags to control HTTP protocol operation.</li> </ol>                                                                                                                                                                                                                                                                                                                                                 |



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| control rendered document appearance in the browser's window.                                                                                                                                                      | <p>2.2 Distinguish static Web page HTML 2, 3 tags from the dynamic HTML 4, 5 tags and browser objects.</p> <p>2.3 Create a DOM tree model for the given HTML document.</p> <p>2.4 Explain the cookie protocol use to track client/server session progress.</p>                                                                                                                                                                                                                                               |
| 3. Explain browser and Web server framework architecture and show how to benefit from this well-standardised client/server reusable design and framework by applying the extension software engineering principle. | <p>3.1 Examine the architecture of a sample web browser.</p> <p>3.2 Explain browser security related parameters.</p> <p>3.3 Examine the architecture of the Apache Web server.</p> <p>3.4 Use Web server configuration files and variables to customise server program.</p> <p>3.5 Discuss the difference between the HTTPS and SHTTP.</p> <p>3.6 Configure a web server to use SHTTP.</p>                                                                                                                   |
| 4. Program interactive Web applications using JavaScript 3GL.                                                                                                                                                      | <p>4.1 Identify main browser built-in objects and JavaScript object-based (OB) language name of each browser's object.</p> <p>4.2 Combine HTML and JavaScript to create dynamic distributed applications by reusing browser and Web server as starting frameworks.</p> <p>4.3 Use XSLT to transform an XML data document into an HTML Web page document.</p> <p>4.4 Use AJAX to create an interactive application.</p> <p>4.5 Use JavaScript libraries such as 3D with SVG for fine graphics production.</p> |
| 5. Develop light, interactive and RESTful Web services based server-side application program using PHP and/or JavaScript.                                                                                          | <p>5.1 Distinguish Web service and the RESTful server-side APIs.</p> <p>5.2 Install NodeJS and develop JavaScript server-side programs.</p> <p>5.3 Demonstrate working knowledge of Web API design and use principles.</p> <p>5.4 Explain the XML set of languages supporting SOAP service based architecture.</p>                                                                                                                                                                                           |
| 6. Utilise open source programs to rapidly implement PKI security infrastructure in the e-commerce Web site design.                                                                                                | <p>6.1 Itemise all PKI elements.</p> <p>6.2 Demonstrate the ability to install and use PKI.</p>                                                                                                                                                                                                                                                                                                                                                                                                              |
| 7. Implement e-commerce PCI compliant payment processing system.                                                                                                                                                   | <p>7.1 Discuss the security problems faced by e-commerce payment processing.</p> <p>7.2 Evaluate the different payment processing system options available.</p> <p>7.3 Differentiate the steps involved in payment processing.</p>                                                                                                                                                                                                                                                                           |
| 8. Conceptualise a cost effective digital                                                                                                                                                                          | <p>8.1 Understand the value and options of marketing.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                    |



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marketing strategy and implement a marketing plan.

- 8.2 Design an appropriate marketing strategy.
- 8.3 Use browser engines to advertise.
- 8.4 Use social media to promote e-commerce site.

## Assessment Methodology

| Assessment Criteria Covered       | Assessment Scenario                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Assessment Method                                                                                                                                                                    | Grading Info (optional)                                     |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| 1.1, 1.2, 1.3, 1.4, 1.5, 2.1, 2.2 | Learner should design layered architecture of the distributed business application and explain the supporting layered systems service architecture. Establish HTTP traffic sniffing system using TELNET protocol client, browser facility or alternative tool and inspect HTTP message exchange flow. Define the purpose of all currently available HTTP command and status key words. Explain how insecure HTTP is and how to transform it into the HTTPS and then to SHTTP. Demonstrate examples of using HTML meta tags to control HTTP. | Review of the learner's work results and documented report with screenshots. Review learner's comments and explanations of meaning of each portion of their report. (Weighted at 8%) | Proper assessment criteria report earns 1+2+1+2+2=8 points. |
| 2.2, 2.3, 2.4, 3.1, 3.2, 4.1      | Explain HTML document description and related DOM model created in the browser's heap memory space. Recognise DOM model problems with very large HTML documents and limited memory space. Draw DOM tree model for the given HTML document and explain custom model node object naming. Present an example of a cookie file and explain the cookie protocol. Demonstrate how to customise the browser and control cookie protocol. Explain the browser architecture.                                                                         | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)                                                                  | Each matched assessment criteria earns 1+1+1+1+2+1=7 points |
| 3.3, 3.4, 3.5, 3.6                | Explain a Web server's default architecture. Demonstrate Web server installation and the changing of security relevant configuration parameters.                                                                                                                                                                                                                                                                                                                                                                                            | Review of the written document and matching portions of the document with the learning objectives.                                                                                   | Each matched assessment criteria earns 2+2+3=7              |



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|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
|                         | Demonstrate default and custom browser object naming used to alter object attributes by means of JavaScript.                                                                                                                                                                                                                                                                                                                                                                                                          | (Weighted at 7%)                                                                                                       | points                                                      |
| 4.3, 4.4, 4.5           | Draw the tree and container DOM browser generated model of a given XML document.<br>Write a sample XSLT "program" to translate an XML document into an HTML document.<br>Install AJAX and write a simple AJAX based application.<br>Demonstrate SVG graphics programming by drawing scalable basic geometric visual objects and fonts.                                                                                                                                                                                | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%) | Each matched assessment criteria earns 1+2+2+2=7 points     |
| 5.1, 5.2, 5.3, 5.4, 5.5 | Explain the Web service based architecture and provide samples of XML languages used.<br>Explain the difference between Web services and RESTful services.<br>Install NodeJS and demonstrate basic node shell use.<br>Create a simple RESTful API on NodeJS.                                                                                                                                                                                                                                                          | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%) | Each matched assessment criteria earns 2+1+2+2=7 points     |
| 6.1, 6.2, 7.1, 7.2, 7.3 | Explain PKI purpose and components.<br>Differentiate automated payment processing steps.<br>Plan all steps involved in applying, installing and using a PCI compliant payment processing system.                                                                                                                                                                                                                                                                                                                      | Review of the written document and matching portions of the document with the learning objectives.<br>(Weighted at 7%) | Each matched assessment criteria earns 1+2+4= 7 points      |
| 8.1, 8.2, 8.3, 8.4      | Differentiate marketing from advertisement and sales.<br>Explain basic marketing strategies and identify one that is suitable for small start-up businesses.<br>Explain how HTML meta tags can be used to promote a site by leveraging the use of search engines and attract the right sort of visitors.<br>Present use case examples of good digital marketing.<br>Explain how social media can be used for the promotion of a new Web site.<br>Present a plan of how to prepare for the next generation of the Web. | Review questions answered and the written report matching portions with the learning objectives.<br>(Weighted at 7%)   | Each matched assessment criteria earns 1+1+2+1+1+1=7 points |
| Project                 | Install NodeJS and develop an example server side application using MySQL                                                                                                                                                                                                                                                                                                                                                                                                                                             | Review of the written project report document                                                                          | Each matched                                                |



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|              |                                                                                                       |                                                                                                                 |                                                                       |
|--------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
|              | database, and JavaScript 3D or alternative library to produce a rich data chart report using SVG.     | and matching portions of the document with the learning assignment objectives. (Weighted at 9%)                 | assessment criteria earns 10 points                                   |
| Midterm test | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts. | Review questions answered and matching portions of the document with the learning objectives. (Weighted at 20%) | Each question properly answered earns 1 point, (Maximum is 20 points) |
| Final test   | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts. | Review questions answered and matching portions of the document with the learning objectives. (Weighted at 20%) | Each question properly answered earns 1 point, (Maximum is 20 points) |



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## STUDY UNIT 7

### Mobile Computing and 5G Networking

MQF Level 7

6 ECTS

E-learning: No

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### Rationale

Mobile computing technology, distributed applications running on the mobile networking infrastructure (apps) and relevant security issues are of paramount importance in the situation where mobile application-based business volume and development industry is growing at a blazing 43% per year with no signs of slowing this trend. Over 16 billion USD are spent yearly on mobile app development and services, which presents a huge opportunity for part time or full-time employment as well as for the self-started business project.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Understand market driven new technology acceptance and technological evolution by examining the history of data and telephone communication systems focusing on wireless data and telephony;
2. Understand how modern mobile telephones have evolved into portable high power computer network nodes implementing sophisticated hardware architectures, using virtual machines, operating systems and a wide spectrum of application programs (apps), with just one app dedicated to the telephony;



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3. Analyse the evolution and sequence of GSM, CDMA, LTE, etc., standard CP networking technologies, leading to IMS and IP networks;
4. Compare 3G, 4G and 5G CP network system solutions by taking into an account that higher data transmission rates and wider signal spectra lead to smaller, more densely distributed costly cells;
5. Integrate wired and wireless networks with the cloud computing infrastructure taking into account the diversity of operating systems, hardware platforms and fluctuating quality of connection services;
6. Analyse the diversity of network traffic, equipment and protocols employed and learn about options of minimising diversity by applying virtualisation of network functions and software definition-based network orchestration;
7. Use and implement mobile payment systems solutions.

## Content – Detailed

1. A historical overview of mobile computing and protocols, legacy telephony, and early wireless telephony is covered in this introductory lecture. Wireless protocols 802.11x and 802.16m, as well as wireless-MAN; and wireless cellular networking; and 1G, 2G, 2.5G, 3G, 4G, packet core evolution is presented.
2. Mobile device hardware architecture as a subject of significant importance in mobile telephony is covered in this lecture. Mobile telephone circuit architecture, Android and iPhone devices, as well as ARM processor based implementations are presented. Virtual smart-phone architecture and wireless signalling with antenna design are presented too.
3. 4G Architecture; LTE & WLAN, Evolved Packet Core (EPC) and 3G cellular network extension to Internet are covered. Routing with mobile nodes and EPC 3GPP core network architecture are presented. GSM (GPRS, EDGE), W-CDMA

(HSPA), LTE (LTE-Advanced, LTE-Advanced Pro) and MIMO techniques in WiMAX under LTE are described.

4. This lecture covers 4G applications; VoLTE (IMS), mobile Internet, cloud access, as well as IMS and all-IP network. Multimedia quality facilities with QoS class identifier are introduced. Personalised services, BYOD, LTE D2D protocol are explained.
5. 5G Architecture, network slicing, 5G New Radio Interface and physical architecture, with the radio access network are discussed. Network slicing, 5G network and IoT networking technologies are introduced in this lecture. Network programmability and the application of virtualisation to mobile networking with the general considerations on VNFs in 5G are presented.
6. 5G application domains, open source toolkits and testbeds are introduced in this lecture. Limitations in 4G architecture are itemised. Private clouds for mobile app services as solutions are described. Mobile device and application management VReality, ESports, drones, MobEd, MobG are described too.
7. Cloud Computing and Mobile Edge Computing (MEC) with the MEC Framework reference architecture functional elements and reference points are topics of this lecture. Mobile edge services, MEC Deployments in 4G are covered. Cloud RAN and MEC use cases are analysed.
8. Mobile operating systems and apps development within such systems are discussed in this lecture. Stratum grouping of protocols Google Android architecture and applications as well as Apple iOS (6 - 11) with the Windows Phone 8 and 10 are discussed.
9. SDN application to mobile computing network control and Virtual Network Functions (VNF) are topics of this lecture. Network device and traffic diversity problems and solutions using SDN control plane and Network Functions Virtualisation (NFV) are addressed. SDN application plane and network

programming applied to traffic engineering and network orchestration and secure network management is covered.

10. The introduction of the high performance computing (HPC) mobile phone has enabled mobile digital payment facilities. Secure mobile payment processing as important e-commerce activity is covered in this lecture. Mobile payment processing devices, mobile money transfer, mobile identity, mobile connect, mobile blockchain applications, transaction verification, restoring past transactions, and mobile wallet are all explained. Operator and bank-centric, collaborative and P2P models are also presented.

## Assessment Criteria

| Learning Outcomes                                                                                                                                                                                                                                                                                      | Assessment Criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                                                                                                                                                                       | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 1. Understand market driven new technology acceptance and technological evolution by examining the history of data and telephone communication systems focusing on wireless data and telephony.                                                                                                        | <p>1.1 Understand that some inventions like the invention of a telephone were accidental discoveries.</p> <p>1.2 Analyse the development of wired telephony and transformation into a wireless technology.</p> <p>1.3 Explain the sequence of cell phone (CP) standards and their characteristics from 1G to 5G.</p> <p>1.4 Compare the wireless LAN standards and their characteristics.</p>                                                                                                                                                                                                                                                                       |
| 2. Understand how modern mobile telephones have evolved into portable high power computer network nodes implementing sophisticated hardware architectures, using virtual machines, operating systems and a wide spectrum of application programs (apps), with just one app dedicated to the telephony. | <p>2.1 Recognise key CPU architecture features in ARM processors and reasons for using such (and similar) processors in mobile devices.</p> <p>2.2 Present schematics of mobile phone systems hardware architecture and support decisions to employ virtualisation in modern CPs.</p> <p>2.3 Explain why some cell phones are equipped with several antennas, as well as the accidental invention of the modern day CP's antenna structure.</p> <p>2.4 Explain market and technology interaction leading to convergence of global data and voice wired and wireless networks.</p> <p>2.5 Explain EPC 3GPP core network architecture and routing protocols used.</p> |



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| 3. Analyse the evolution and sequence of GSM, CDMA, LTE, etc., standard CP networking technologies, leading to IMS and IP networks.                                                                                                | <p>3.1 Compare and contrast the European and American CP network development paths.</p> <p>3.2 Explain the network convergence trend of global CP network solutions being transformed into IP multimedia networks.</p> <p>3.3 Explain the QoS implementation in CP networks.</p> <p>3.4 Evaluate personalisation services in CP networks.</p> <p>3.5 Critically evaluate a relevant technical paper on MIMO application to WiMAX and LTE.</p>                                                                                                                                             |
| 4. Compare 3G, 4G and 5G CP network system solutions by taking into an account that higher data transmission rates and wider signal spectra lead to smaller, more densely distributed costly cells.                                | <p>4.1 Analyse the characteristics of voice as analogue data type and its encoding and digital transmission options.</p> <p>4.2 Explain the parallel existence of voice and data CP networks.</p> <p>4.3 Explain conflicting requirements for total mobility including worldwide connectivity, high data throughput, high QoS, top security with privacy at the lowest cost.</p> <p>4.4 Analyse the technical features of 5G CP network solutions that may resolve conflicts of 4.3.</p> <p>4.5 Evaluate general sorts of services such as: VReality, ESports, drones, MobEd, MobGov.</p> |
| 5. Integrate wired and wireless networks with the cloud computing infrastructure taking into an account the diversity of operating systems, hardware platforms and fluctuating quality of connection service.                      | <p>5.1 Discuss cloud computing access solutions.</p> <p>5.2 Evaluate technical requirements for Mobile Edge Computing (MEC) and CP-Cloud integration.</p> <p>5.3 Present the architecture of the Apple iOS and Android operating systems.</p> <p>5.4 Identify protocols that the CP OS must support.</p> <p>5.5 Differentiate between UMTS domains and strata.</p>                                                                                                                                                                                                                        |
| 6. Analyse the diversity of network traffic, equipment and protocols employed and learn about options of minimising diversity by applying virtualisation of network functions and software definition-based network orchestration. | <p>6.1 Distinguish between NFV and VNF.</p> <p>6.2 Use NFV to faster deploy new services and bring it to market while reducing CAPEX and OPEX and end consumer service price.</p> <p>6.3 Explain design concept of dynamic service chaining for VNFs using SDN approach.</p> <p>6.4 Use NFV to simplify CP network and cloud integration.</p> <p>6.5 Summarise modern CP network trend with NFV/SDN and NFV/Cloud technologies.</p>                                                                                                                                                       |
| 7. Use and implement mobile payment systems solutions.                                                                                                                                                                             | <p>7.1 Design a mobile payment supported point of sale (POS) business network node.</p> <p>7.2 Select credit card payment processing hardware and software needed for implementing a totally mobile POS.</p> <p>7.3 Install, configure and use a CP-based mobile banking</p>                                                                                                                                                                                                                                                                                                              |



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- terminal.
- 7.4 Examine the protocol steps required for processing mobile payment or mobile bank transaction.

## Assessment Methodology

| Assessment Criteria Covered  | Assessment Scenario                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Assessment Method                                                                                                                                                                                  | Grading Info (optional)                                           |
|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| 1.1, 1.2, 1.3, 1.4, 2.3, 3.1 | <p>Perform Web research and present a minimum of two cases of accidental engineering discoveries.</p> <p>Explain Bell's accidental discovery of voice transmission over the copper wire and the importance of the open observance in creativity and innovation process.</p> <p>Analyse the shape of modern cell phone (CP) antenna and explain the creativity process involved in the particular antenna shape discovery.</p> <p>Specify differences between early European and US mobile telephony developments.</p> <p>Explain the evolution of the WiFi standard leading to faster and more secure wireless LAN cell products.</p> <p>Select two wireless or mobile telephony cases and explain market and technology developments and correlation, explaining how these developments drive each other.</p> <p>Determine major 802.11 version speeds and ranges.</p> | <p>Review of the learner's work results and documented report with screenshots.</p> <p>Review learner's comments and explanations of meaning of each portion of their report. (Weighted at 7%)</p> | <p>Proper assessment criteria report earns 7x1=7 points.</p>      |
| 2.1, 2.2, 2.4, 2.5           | <p>Explain the elementary single core CPU architecture.</p> <p>Explain Von Neuman's single bus computing system architecture and compare it to the hierarchical architectures using bridges and hubs.</p> <p>Specify major differences between ARM processors and common PC processors.</p> <p>Draw the mobile phone</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <p>Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)</p>                                                                         | <p>Each matched assessment criteria earns 1+1+2+2+1= 7 points</p> |



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|                         | architecture/block and circuit diagrams.<br>Explain EPC 3GPP core network architecture.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                     |                                                             |
| 3.2, 3.3, 3.4, 3.5      | Analyse GSM documentation and specify important attributes.<br>Analyse CDMA documentation and specify important attributes.<br>Analyse LTE documentation and specify important attributes and benefits.<br>Explain the benefits of using IP protocol for all data type transmissions.<br>Perform a take-home study of a technical paper on MIMO application to WiMAX and LTE and present a report on the major points of the papers.                                                                                                                       | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%) | Each matched assessment criteria earns 1+1+2+1+2=7 points   |
| 4.3, 4.4, 4.5           | Differentiate voice audio and video data types and specify relevant file formats in use.<br>Compare legacy PCM and modern voice encoding schemes.<br>Explain the reason for the parallel existence of multiple signal and media networks on the same mobile network.<br>Compare 3G and 5G technologies and specify basic key performance indicators (KPIs) and relevant quality of service (QoS) parameters of each technology.<br>Explain how the 5G network improves QoS.<br>Compare different high-level services such as VReality, ESports, and MobEd. | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 9%) | Each matched assessment criteria earns 1+2+1+2+1+2=9 points |
| 5.1, 5.2, 5.3, 5.4, 5.5 | Demonstrate understanding of the network slicing principle by applying it to the creation of slices of physical resources devoted to logical, self-contained, partitioned network functions.<br>Show the ability to perform simple independent design work in an isolated physical network component layer and logical software-based layer.<br>Specify main cloud computing characteristics and general levels of services.                                                                                                                               | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%) | Each matched assessment criteria earns 5x1+2=7 points       |



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|------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
|                              | <p>Explain Mobile Edge Computing.<br/>Highlight protocols used to access the cloud.<br/>Define UMTS and explain strata.</p>                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                      |                                                                |
| 6.1, 6.2, 6.3, 6.4, 6.5      | <p>Define the concept of virtualisation.<br/>Itemise network functions and devices that are virtualised in modern developments.<br/>Explain the difference between CAPEX and OPEX and explain which of the two is more reduced by virtualisation.<br/>Explain how virtualisation complements cloud computing.<br/>Explain how SDN complements cloud computing.<br/>Explain how virtualisation, SDN and cloud computing technologies enable rapid and affordable growth of modern mobile networks.</p> | <p>Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)</p>                           | <p>Each matched assessment criteria earns 5x1+2=7 points</p>   |
| 7.1, 7.2, 7.3, 8.1, 8.2, 8.3 | <p>Design a mobile phone payment enabled fixed point of sale (POS) system.<br/>Design a mobile POS capable of accepting credit cards and mobile phone payment including Bitcoin payment.<br/>Specify the overall protocol of electronic payment processing.<br/>Produce consulting documentation to a merchant on how to evaluate the security of the electronic payment system whilst maintaining PCI compliance.<br/>Specify requirements for implementing mobile banking.</p>                      | <p>Review questions answered and the written report matching portions with the learning objectives. (Weighted at 7%)</p>                             | <p>Each matched assessment criteria earns 2+2+3x1=7 points</p> |
| Project                      | <p>Use JavaScript technology with Google Firebase to develop a simple mobile phone application specified by the instructor or by the learner.</p>                                                                                                                                                                                                                                                                                                                                                     | <p>Review of the written project report document and matching portions of the document with the learning assignment objectives. (Weighted at 9%)</p> | <p>Each matched assessment criteria earns 9 points</p>         |
| Midterm test                 | <p>Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts.</p>                                                                                                                                                                                                                                                                                                                                                                                          | <p>Review questions answered and matching portions of the document</p>                                                                               | <p>Each question properly</p>                                  |



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|            |                                                                                                       |                                                                                                                 |                                                                       |
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|            |                                                                                                       | with the learning objectives. (Weighted at 20%)                                                                 | answered earns 1 point, (Maximum is 20 points)                        |
| Final test | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts. | Review questions answered and matching portions of the document with the learning objectives. (Weighted at 20%) | Each question properly answered earns 1 point, (Maximum is 20 points) |



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## STUDY UNIT 8

### Internet of Things (IoT)

MQF Level 7

6 ECTS

E-learning: No

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### Rationale

With tens of billions of smart devices in use and their massive network connection, the importance of IoT technologies cannot be downgraded. The technology of networking intelligent things to enhance life quality, safety and productivity is one of the imperatives of the computing powered living of the modern global citizen. A huge emerging job market makes this IoT technology course necessary in any modern information technology and systems sort of curricula.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Understand the embedded computing technology and solution options available when building an intelligence extension of physical non-electronic objects;
2. Analyse the influence of the falling costs of hardware, software and wireless communications on the emergence of the new markets with universal networking of non-electronic devices and ordinary things;
3. Differentiate between M2M communication protocol options and design procedures of the Industrial IoT (IIoT) and automotive road vehicles IoT networks;



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4. Design intelligent homes, high-rise buildings, and propose products to be deployed in smart city systems;
5. Understand the Internet and IoT interface solutions and features including the required hardware and software to integrate IoT and the Internet;
6. Analyse different opportunities for IoT applications for tourist attractions and entertainment stage performance, and relate analysis results to potential products involving cloud computing services and available development and implementation tools;
7. Integrate various cloud services and the IoT network of sensors and actuators;
8. Secure IoT data collection into a cloud based server, perform massive data analytic transformation in the cloud and generate user friendly graphics enhanced reports.

## Content – Detailed

1. Fundamentals of embedded computing are introduced in this lecture. The state-machine based wired firmware controllers are explained as the most cost and energy-effective solutions in massive deployment of IoT devices. Microprocessor and device firmware use for embedded IoT design are considered and embedded computing and communication limitations are explained.
2. IoT as super-sized network running new type of distributed applications is described in this lecture. Falling hardware cost, growing network infrastructure and advances in rapid software development are analysed as the contributing factors to the spreading of IoT use. Massive hardware use and cost reduction are correlated. Software, computing hardware and non-electronic devices synergy useful to build IoT nodes in the IoT network are presented.
3. Wireless sensor and ad-hoc network protocols are introduced in this lecture. Hybrid routing protocols for wireless sensor network are presented. A

comparison of different wireless sensor and actuator networks is made and their application is described.

4. Machine-to-Machine (M2M) communication protocols such as: Field Bus, Zigbee, CAN, igFOX, 6LoPAN are presented. M2M IoT link protocols, IoT routed protocols and IoT application layer protocols are presented. Protocol comparison and protocol selection criteria are presented as well.
5. IoT based smart vehicles and plants are the main subjects of this lecture. Motorised vehicles, such as cars, IoT wired and wireless networks using various protocols are described. Smart factory IoT device networking using previously described M2M protocols is introduced. Moving vehicles trust-based routing protocol for ad-hoc networks and their security problems are discussed.
6. Smart buildings and smart cities are discussed in this lecture. Examples of monitoring and control of water, sewer networks and electric grid are described. Traffic monitoring and control to optimise traffic flow using IoT technology is considered in this lecture too.
7. IoT application layer protocols such as: HTTP, COAP, MQTT, AMPS Legacy Internet are discussed and compared in this lecture. Web-bound IoT protocols using HTTP are explained. Short vs. long message and standard vs. custom protocols use when optimising application performance and security is considered.
8. IoT open source and custom application development approaches to IoT application development are the subjects of this lecture. Examples of IoT sports and tourist attraction event applications are presented. Azure IoT suite Software Development Kit (SDK) and Application Programming Interface (API) enabled platforms and similar offerings are considered. IoT related open source tools, sample projects and platforms such as Kinoma, ARM Mbed, Snappy Core, and Node Red, are presented and proposed to learners for practical exercise.

9. SDN control and cloud computing application to massive IoT networks are subjects of this lecture. The cloud interface of IoT, massive IoT collected data management and predictive data analytics are presented. Predictive data analytics and SDN relevant learner projects are explained.
10. IoT data analytics and security issues are considered in this lecture. Hardware and software security related issues with examples of IoT security incidents are discussed. Methods of defending IoT networks and devices under tight computing, energy and communication constraints are described. Enterprise IoT and cloud computing applications to IoT data collection and processing for analytics purposes is presented. In addition, real time graphical reporting of IoT device activities is covered too.

## Assessment Criteria

| Learning Outcomes                                                                                                                                                                                            | Assessment Criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                                                                             | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 1. Understand the embedded computing technology and solution options available when building an intelligence extension of physical non-electronic objects.                                                   | <ol style="list-style-type: none"> <li>1.1 Differentiate embedded computing options to be applied to fixed or mobile objects, and large, small or miniaturised objects.</li> <li>1.2 Analyse the difference between the state machine controller and microprocessor controller.</li> <li>1.3 Determine the limitations of embedded electronics devices particularly computational processing, communications and power sources.</li> <li>1.4 Design the architecture of an embedded controller capable of wireless communications.</li> </ol> |
| 2. Analyse the influence of the falling costs of hardware, software and wireless communications on the emergence of the new markets with universal networking of non-electronic devices and ordinary things. | <ol style="list-style-type: none"> <li>2.1 Perform a historical study of prices and sales volumes of microprocessors and memories.</li> <li>2.2 Perform a historical study of prices and sales volumes of operating systems.</li> <li>2.3 Perform a historical study of prices and sales volumes of mobile telephony devices.</li> <li>2.4 Conceptually design a thing of choice extended with embedded computing and cell phone communication capability.</li> </ol>                                                                         |



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|                                                                                                                                                           | <p>2.5 Identify practical situations and products that can benefit from the use of wireless sensor networks.</p> <p>2.6 Design bridge solutions between sensor link and IP compatible networks.</p> <p>2.7 Analyse protocols capable of supporting wireless sensor networks.</p>                                                                                                                                                                                                                                                                                                                                                                                                 |
| 3. Differentiate between M2M communication protocol options and design procedures of the Industrial IoT (IIoT) and automotive road vehicles IoT networks. | <p>3.1 Analyse the characteristics of ad-hoc networking and problems involving physical layer and higher layer protocol selection.</p> <p>3.2 Present a design of a motorised road vehicle sensor and actuator network.</p> <p>3.3 Analyse the basic architecture of the smart driverless vehicle computing system, covering the principle aspects of the hardware and software used.</p> <p>3.4 Propose applications for wireless and wired motorised vehicle IoT networking.</p> <p>3.5 Compare the 6LoPAN and Zigbee protocols and highlight their pros and cons when used for wireless networks of devices.</p> <p>3.6 Implement an RFID tag and reader hardware system.</p> |
| 4. Design intelligent homes, high-rise buildings, and propose products to be deployed in smart city systems.                                              | <p>4.1 Examine all home devices that can be made smart.</p> <p>4.2 Use or customise existing secure protocols to protect a home network from malicious access.</p> <p>4.3 Propose an alarm system design that may report in hierarchy, to owner, alarm company, fire department and police department.</p> <p>4.4 Design a smart home for the disabled.</p> <p>4.5 Design a mobile phone and IP network based home surveillance system.</p> <p>4.6 Design a traffic monitoring system and propose a Web service to report traffic problems.</p> <p>4.7 Identify which smart city application could benefit from MIMO wireless connected IoT devices.</p>                         |
| 5. Understand the Internet and IoT interface solutions and features including the required hardware and software to integrate IoT and the Internet.       | <p>5.1 Inspect the basic configuration requirements of the Internet node.</p> <p>5.2 Design an IPv4 tunnel for transporting IPv6 and 6LoPAN traffic.</p> <p>5.3 Design a gateway hardware and software device to bridge between unmatched network protocols found in IoT applications.</p> <p>5.4 Design an IoT database.</p> <p>5.5 Design secure access to the IoT database.</p>                                                                                                                                                                                                                                                                                               |



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| 6. Analyse different opportunities for IoT applications for tourist attractions and entertainment stage performance, and relate analysis results to potential products involving cloud computing services and available development and implementation tools. | 6.1 Observe the market and business enterprise situations and evaluate the possible opportunity situations for IoT applications.<br>6.2 Identify currently available IoT product software development tools, SDK, APIs, frameworks, Web and cloud services.<br>6.3 Use Azure IoT suite.<br>6.4 Evaluate currently available products used in the cloud and produce a report highlighting outstanding products.                                         |
| 7. Integrate various cloud services and the IoT network of sensors and actuators.                                                                                                                                                                             | 7.1 Identify all cloud computing services applicable to the IoT.<br>7.2 Propose a subset of identified services in 7.1, which may be used to complement predictive analytics work on IoT data.<br>7.3 Determine the infographics specifications that employ thought-leading techniques and deliver deeper insights.<br>7.4 Design and produce an infographics DSS enabling report.                                                                     |
| 8. Secure IoT data collection into a cloud based server, perform massive data analytic transformation in the cloud and generate user friendly graphics enhanced reports.                                                                                      | 8.1 Design an IoT short message transaction processing database.<br>8.2 Transform a transaction IoT database into an analytical database.<br>8.3 Apply statistical and machine learning data analysis algorithms onto IoT data.<br>8.4 Use NodeJS and JavaScript or alternative software engineering technology to generate real-time charting reports.<br>8.5 Propose an attack detection (Intrusion detection) solution based on the data collected. |

## Assessment Methodology

| Assessment Criteria Covered | Assessment Scenario                                                                                                                                                                                                             | Assessment Method                                                                                | Grading Info (optional)                              |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|------------------------------------------------------|
| 1.1, 1.2, 1.3, 1.4, 2.5     | Use a state-transition diagram and design a simple state machine controller.<br>Design a simple embedded computing device using off-the-shelf parts.<br>Design an embedded computer architecture and identify I/O devices used. | Review of the learner's work results and documented report with screenshots.<br>Review learner's | Proper assessment criteria report earns 4x2= 8 point |



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|                         | Perform Web research and present a minimum of two cases of IoT home alarm system applications.                                                                                                                                                                                                                                                                                                                                                                                                                                                             | comments and explanations of meaning of each portion of their report. (Weighted at 8%)                              |                                                                |
| 2.1, 2.2, 2.4, 2.5      | Use Web searching engine query language to collect analytical data and perform historical electronics market performance study.<br>Perform historical sales analysis on processors and memories and produce a report documenting trends.<br>Analyse history of use and sales of mobile telephony products and indicate major technological generation milestone dates.<br>Analyse how the modern CPAP machine reports everyday patient snoring behaviour using a wireless modem.                                                                           | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 8%) | Each matched assessment criteria earns 4x2=8 points            |
| 3.1, 3.2, 3.3, 3.4, 3.5 | Describe three smart machine IoT use cases.<br>Define IIoT and its application impact toward safety at work.<br>Draw a smart car IoT network and identify the protocols used.<br>Identify the weak security spots in the modern car IoT networks.<br>Describe three well-reported car accidents involving possible car hacking attacks.<br>Explain the design of the smart motorway and ad-hoc car network.                                                                                                                                                | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%) | Each matched assessment criteria earns 1+1+2+3x1=7 points      |
| 3.5, 3.6, 3.7           | Distinguish the differences between the specifications of the IoT bridge and the IoT hub.<br>Explain all header variables in the 6LoPAN packet.<br>Explain how was IPv6 header reduced in 6LoPAN.<br>List wireless link protocols and identify which could be used for personal area network (PAN) applications.<br>Present a use case of the Zigbee protocol application in an industrial environment.<br>Design an RFID key-card based office door lock system.<br>Explain how and why the IPv6 protocol was modified to the present 6LoPAN internetwork | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 8%) | Maximal matched assessment criteria earns total 2+7x1=8 points |



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|                                   | protocol.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                    |                                                                                                  |
| 4.1, 4.2, 5.1, 5.2, 5.3, 5.4, 5.5 | <p>Differentiate between three household devices that could be made smart and could generate a large profit to the manufacturer of an IoT embedded device.</p> <p>Propose a traditional sample home redesign employing security devices and services .</p> <p>Propose networking protocols that could make the home IoT network safer.</p> <p>Analyse one sort of disability and design an appropriate IoT home network that could enhance the life of a disabled resident.</p> <p>Specify the equipment required and produce the project cost accounting report for the sample home surveillance project.</p> <p>Design a MIMO network suited toward multimedia home devices.</p> <p>Identify the most appropriate type and brand of a sensor to be used to monitor street traffic frequency and vehicle size.</p> | <p>Review of the written document and matching portions of the document with the learning objectives.</p> <p>(Weighted at 10%)</p> | <p>Maximal matched assessment criteria earns <math>4 \times 1 + 2 + 3 + 1 = 10</math> points</p> |
| 6.1, 6.2, 6.3, 6.4                | <p>Propose an IoT network for the smart hotel.</p> <p>Identify IoT devices that could make a hotel room safer.</p> <p>Propose an RFID based IoT device that could make a tourist's baggage safer.</p> <p>Discuss the possibility of tracking a soccer ball by an embedded IoT device, collecting data and reporting ball usage and analytic data in the Azure Cloud.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                            | <p>Review of the written document and matching portions of the document with the learning objectives.</p> <p>(Weighted at 7%)</p>  | <p>Maximal matched assessment criteria earns <math>1 + 3 \times 2 = 7</math> points</p>          |
| 7.1, 7.2, 7.3                     | <p>Compare different cloud services and identify the products that can be used for rapid and cost effective IoT application development.</p> <p>Evaluate different IoT product development tools.</p> <p>Define basic advantages of using infographic reports to enhance the decision-making process.</p> <p>Present three examples of a good infographic report.</p> <p>Examine six infographic sample reports and describe the most frequently found visual objects in the examined reports.</p>                                                                                                                                                                                                                                                                                                                  | <p>Review questions answered and the written report matching portions with the learning objectives.</p> <p>(Weighted at 7%)</p>    | <p>Each matched assessment criteria earns <math>3 \times 1 + 2 + 2 = 7</math> points</p>         |
| Project                           | <p>Select one RaspberryPi project from the suggested list or propose an alternative, implement it, demonstrate its use and write a</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>Review of the written project report document and</p>                                                                           | <p>Each matched assessment</p>                                                                   |



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|              | suitable report supporting all stages of the project including: design documentation, project cost accounting, possible project application and market potential. | matching portions of the document with the learning assignment objectives.<br>(Weighted at 10%)                    | criteria earns 10 points                                              |
| Midterm test | Answer the list of 15 questions demonstrating understanding of the relevant terminology and concepts.                                                             | Review questions answered and matching portions of the document with the learning objectives.<br>(Weighted at 15%) | Each question properly answered earns 1 point, (Maximum is 15 points) |
| Final test   | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts.                                                             | Review questions answered and matching portions of the document with the learning objectives.<br>(Weighted at 20%) | Each question properly answered earns 1 point, (Maximum is 20 points) |



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## STUDY UNIT 9

### Financial Computing and Cryptocurrencies

MQF Level 7

6 ECTS

E-learning: No

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### Rationale

This unit represents a compact introduction to computation driven financial instruments, their trading mechanisms, financial markets management, and banking, devoting particular attention to the phenomena of electronic currency and blockchain technologies. The potential of electronic currencies and the threats that such currencies pose to the existing financial market instruments requires a profound understanding of this "phenomena" and as such deserves particular attention demonstrated in this unit. In addition, security threats that electronic currency systems are exposed to, and potential losses that users of such systems may suffer, requires formal analysis to be clearly presented. Also presented is the option for the learners to design their own custom cryptocurrency or blockchain-based product.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Distinguish different value exchange equivalence token use, and compare it to money as traditional value equivalence, using value parameter agreement between such token users;



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2. Discuss the various trading systems such as currency exchange, stock exchange, trading of papers of value, with the focus of defining major financial instruments found in modern financial markets;
3. Understand hash functions and blockchain algorithms;
4. Explain the practical user approach to Bitcoin, install a Bitcoin wallet, use wallet at Bitcoin exchanges, and purchase goods or services using Bitcoin.
5. Setup a Bitcoin mining program using JavaScript or PHP and protect a workstation from the hidden viral Bitcoin miners;
6. Analyse the capabilities of Ethereum and other Bitcoin alternative products;
7. Design and install a digital currency enabled point of sale (POS) system;
8. Discuss the different digital currency threats and security issues.

## Content – Detailed

1. A historical overview of the phenomena of money and concepts of value are presented as an introductory topic in this lecture. The barter exchange and emergence of money is explained. Standard coinage and the ancient Roman banking system, as well as later use of the banknotes and value papers are also covered.
2. Currency and banking concepts are explained. Measuring worth or value, market concepts, as well as inflating and deflating value are explained too. Banking principles, gold deposits and other forms of reinforcing currency acceptance are discussed. The concept of digital currency is introduced.
3. Currency exchange roles and operations are introduced in this lecture. The currency concept and currency evaluation are explained with respect to exchange operation with the presentation of the basic principles of exchange rates. Value outflow due to currency asymmetry is introduced and the static and dynamic approach to value conservation is described. Electronic currency conversion rates are covered too.

4. Financial instruments and the trading of such instruments are discussed in this lecture. Examples of financial instruments such as stocks, bonds, and options are discussed. Financial markets, institutions, Forex market concepts are explained in a way that is acceptable to an ICT professional. Digital and virtual-financial instruments are also addressed. Algorithmic trading and arbitration are covered too.
5. One-way hash algorithms, as discussed in previous lectures is expanded upon in this lecture. The application of hash functions to reliable and secure data record management is introduced. The concept of the digital signature is extended to the blockchain algorithm and reliable transaction logging.
6. Following up on the previous lecture, the blockchain algorithm, as one profound application of hashing algorithms, is explained in this lecture. Blockchain algorithm principles and practical examples are demonstrated. Non-financial use cases such as e-government or reliable and trusted monitoring data tracking is presented. Developing trust-based applications is presented as an opportunity for creative business model development.
7. The Bitcoin phenomena and alternative electronic currencies are described in this lecture. Fundamental principles of digital currency are presented. Satoshi Nakamoto's paper is analysed and the electronic cash system is described. Bitcoin's revolution as a financial, technological and social phenomena is analysed. Using Bitcoin as a digital financial instrument in the new wave financial market is discussed. Alternative digital cash systems are presented and future possibilities are described.
8. Ethereum, as a blockchain application development platform, is discussed in this lecture. Smart digital contract is explained and use of the Ethereum to program smart contract system is described. Building diverse Ethereum based trusted applications is also discussed. The creation of a democratic

autonomous organisation based on the blockchain algorithm option is considered as an opportunity and will also be presented.

9. Securing the electronic wallet and the digital cash point of sale system design are subjects of this lecture. Security exposure of the digital currency payment session and protection mechanisms are discussed.
10. Electronic currency security, risk assessments, and possible protection measures are presented in this lecture. Personal computing, Internet, smart-phone, digital wallet and IoT evolution has led to this new-age electronic currency use possibilities and also to new forms of security threats. Malicious electronic currency manipulations and security accidents causing massive losses of electronic currency are discussed. The greatest threats to the use of cryptocurrencies are analysed.

## Assessment Criteria

| Learning Outcomes                                                                                                                                                                  | Assessment Criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                                                   | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 1. Distinguish different value exchange equivalence token use, and compare it to money as traditional value equivalence, using value parameter agreement between such token users. | <ol style="list-style-type: none"> <li>1.1 Define and explain value and value equivalence token use.</li> <li>1.2 Examine the history of money and currency from, bones with beads, over clay tablets, metal coins, over paper notes to digital data as value tokens.</li> <li>1.3 Explain how the value or worth of some object or service can be measured.</li> <li>1.4 Explain mechanisms of the value-token value inflation and deflation.</li> <li>1.5 Explain the evolution of banking as value-token management and protection system.</li> </ol> |
| 2. Discuss the various trading systems such as currency exchange, stock exchange, trading of papers of value, with the focus of defining major financial instruments found in      | <ol style="list-style-type: none"> <li>2.1 Define currency and relate it to banking.</li> <li>2.2 Analyse the basic banking business process and new banking requirements.</li> <li>2.3 Explain the purpose of the central bank and its role in fair integration of the world.</li> <li>2.4 Define the meaning of financial instruments and</li> </ol>                                                                                                                                                                                                   |



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| modern financial markets.                                                                                                                                   | <p>mechanisms of their trading.</p> <p>2.5 Discuss the role of the stock exchange.</p> <p>2.6 Explain the procedure of opening a stock trading account.</p> <p>2.7 Explain public currency trading system, such as Forex.</p> <p>2.8 Discuss the pros and cons of algorithmic trading.</p>                                                                                                                                                                                                                                                   |
| 3. Understand hash functions and blockchain algorithms.                                                                                                     | <p>3.1 Compute hash function values.</p> <p>3.2 Compare different hash functions and their result collision.</p> <p>3.3 Specify parameters of the good hash function to be used for the digital signature or chain of accounting documents.</p> <p>3.4 Understand Satoshi Nakamoto's paper and explain the blockchain algorithm.</p> <p>3.5 Explain the trusted mobile idea, customer related value and how the blockchain algorithm is used.</p> <p>3.6 Propose a trust-enhancing application to employ hash and blockchain algorithms.</p> |
| 4. Explain the practical user approach to Bitcoin, install a Bitcoin wallet, use wallet at Bitcoin exchanges, and purchase goods or services using Bitcoin. | <p>4.1 Discuss principles of digital currency.</p> <p>4.2 Create a Bitcoin account and Bitcoin wallet.</p> <p>4.3 Explain the principles of Bitcoin mining and technical options that one miner may consider.</p>                                                                                                                                                                                                                                                                                                                            |
| 5. Setup a Bitcoin mining program using JavaScript or PHP and protect a workstation from the hidden viral Bitcoin miners.                                   | <p>5.1 Implement a procedure of blocking hidden cryptocurrency miners on a PC.</p> <p>5.2 Explain the Bitcoin mining procedure and perform a cost analysis for the establishment of a mining server using various processing capabilities.</p>                                                                                                                                                                                                                                                                                               |
| 6. Analyse the capabilities of Ethereum and other Bitcoin alternative products.                                                                             | <p>6.1 Explain the contract evolution procedure and present a UML model describing contract phases.</p> <p>6.2 Design a smart and reliable digital contracting system.</p> <p>6.3 Explain how Ethereum may be reused to build new applications that require trust and spoof free identification.</p>                                                                                                                                                                                                                                         |
| 7. Design and install a digital currency enabled point of sale (POS) system.                                                                                | <p>7.1 Describe all POS system components and design relevant physical security extension.</p> <p>7.2 Design a POS system capable of accepting all forms of digital payment including Bitcoin via mobile smart phones.</p> <p>7.3 Process Bitcoin payments.</p>                                                                                                                                                                                                                                                                              |





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| 8. Discuss the different digital currency threats and security issues. | <p>8.1 Discuss the vulnerabilities of a digital currency system.</p> <p>8.2 Analyse three cases of digital currency exchange attacks and document losses of the anonymous losers.</p> <p>8.3 Discuss possible government regulatory threats to digital currency.</p> <p>8.4 Analyse media reported cases of malicious digital currency trading incidents.</p> |
|------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Assessment Methodology

| Assessment Criteria Covered       | Assessment Scenario                                                                                                                                                                                                                                                                                                                    | Assessment Method                                                                                                                                                                    | Grading Info (optional)                                   |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|
| 1.1, 1.2, 1.3, 1.4, 1.5, 2.1      | Write an essay on the history of trading, currency, and banking. Explain market mechanisms and value fluctuation of any item in the market. Explain the process of introducing new currency volume issues.                                                                                                                             | Review of the learner's work results and documented report with screenshots. Review learner's comments and explanations of meaning of each portion of their report. (Weighted at 7%) | Proper assessment criteria report earns 3+2+2=7 points    |
| 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8 | Analyse the banking business process. Explain how the central bank controls currency exchange rate fluctuations. Define six major financial instruments and how trading can be beneficial to a company. Explain the purpose of Forex and how to open trading account.                                                                  | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 8%)                                                                  | Each matched assessment criteria earns 4x2=8 points       |
| 3.1, 3.2, 3.3, 3.4, 3.5, 3.6      | Distinguish between good and bad hash function. Explain the use of the hash function to create a digital signature and blockchain ledger data object. Use blockchain simulator and perform building ledger simulation. Explain why blockchain is hard to forge. Propose a business application that could benefit from blockchain use. | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 9%)                                                                  | Each matched assessment criteria earns 1+1+2x2+3=9 points |



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*"Investing in human capital to create more opportunities and promote the well-being of society"*  
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 Co-financing rate: 80% European Union; 20% National Funds





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2014-2020



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|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| 4.1, 4.2, 4.3, 5.1, 5.2 | Produce a manual on how to establish a Bitcoin wallet, how to purchase Bitcoin, how to pay using Bitcoin and how to trade Bitcoin. Produce a manual for a potential Bitcoin miner, how to establish a mining system and how to select the most cost-effective solution. Produce a manual for a potential user on how to defend a PC from hidden Bitcoin miners. | Review of the written document and grade matching portions of the document with the learning objectives. (Weighted at 8%)                      | Maximal matched assessment criteria earns total 2+3+3=8 points |
| 5.1, 5.2                | Explain how a Web server can be used to build a hidden Bitcoin miner by abusing Web site visitors CPU ticks. Perform UML modelling of the contract negotiation parties and document the steps taken. Describe how a contract can end prematurely, and what steps may be taken to enforce the contract in Cyberspace. Analyse three Ethereum use cases.          | Review of the written document and grade matching portions of the document with the learning objectives. (Weighted at 8%)                      | Maximal matched assessment criteria earns 4x2=8 points         |
| 6.1, 6.2, 6.3           | Explain the main components of the modern POS system. Design a Bitcoin payment extension of the POS system. Perform UML modelling of the credit card payment procedure and Bitcoin payment processing procedure and describe the pros and cons of using one over the other. List possible attacks on Bitcoin and optional defence measures.                     | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 10%)                           | Maximal matched assessment criteria earns 2+3+3+2=10 points    |
| Project                 | Use JavaScript or Python and either develop your own or reuse an existing open-source program to implement a Bitcoin miner. Document your work and demonstrate the operation of the miner.                                                                                                                                                                      | Review of the written project report document and matching portions of the document with the learning assignment objectives. (Weighted at 15%) | Maximal matched assessment criteria earns 15 points            |
| Midterm test            | Answer the list of 15 questions demonstrating understanding of the                                                                                                                                                                                                                                                                                              | Review questions answered and matching portions of                                                                                             | Each question                                                  |



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*"Investing in human capital to create more opportunities and promote the well-being of society"*  
 Project part-financed by the European Social Fund  
 Co-financing rate: 80% European Union; 20% National Funds





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|            | relevant terminology and concepts.                                                                    | the document with the learning objectives.<br>(Weighted at 15%)                                                    | properly answered earns 1 point,<br>(Maximum is 15 points)               |
| Final test | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts. | Review questions answered and matching portions of the document with the learning objectives.<br>(Weighted at 20%) | Each question properly answered earns 1 point,<br>(Maximum is 20 points) |



Operational Programme II – European Structural and Investment Funds 2014-2020  
*“Investing in human capital to create more opportunities and promote the well-being of society”*  
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## STUDY UNIT 10

### Entrepreneurship and Innovation Management

MQF Level 7

6 ECTS

E-learning: Yes

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### Rationale

The on-going transformation of the world into a global village with the market globalisation, introduces previously unimaginable opportunities to creative entrepreneurs at all corners of the world. A tsunami of new emerging technologies such as cloud computing, mobile communications and IoT, have elevated the importance of the innovation, particularly incremental innovation, as a vital business element. This unit presents a compact approach to a new profitable business venture establishment that secures growth based on the well-protected original idea or solution. This unit is bridging a gap that commonly exists between mostly technical and mostly business-oriented professionals.

### Learning Outcomes

Upon successful completion of this study unit, the learner will be able to:

1. Understand the procedure of legally establishing a business operation with liability and tax implications involved with the different business forms;
2. Understand the basic process of market bound innovation and how to creatively take a product or service and transform it into a successful business;
3. Manage projects, create a sale and realise all steps necessary to be profitable business;



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4. Maintain business paper documents required by the government that is sponsoring the business environment;
5. Examine state and local taxation laws and gain awareness of fair business practices and dangers of negligence problems;
6. Plan effective low-cost marketing and promotion campaigns;
7. Produce a business plan, plan capitalisation fundraising, recruit investors, sell stock or bonds;
8. Understand the common errors made by the new and long-time existing business, with recommendations on how to approach starting a business while minimising the chances of failure.

## Content – Detailed

1. An introduction to business is presented in this concluding unit of the programme. Questions on whether to incorporate or not are elaborated upon. Definitions of business, mission and strategies and tactics are clarified as important concepts for the successful development of the new business organisation. Legal forms of business, Doing Business As (DBA) proprietorships, partnerships, Limited Liability Corporations (LLC), and full corporations are differentiated. Tax benefits and liability risks of different legal business forms and full corporation exposure, risks and benefits are explained.
2. The strategic approach to a high business potential innovative product or service development and protection are topics of this lecture. Product innovation elementary rules are introduced as guidelines to a creative approach to business. Successful cases are discussed and recommendations how to replicate other business organisation success by introducing improvements and complementary products or/and services. Low cost, standard vs. high cost, and exceptional offering are considered. Patent, copyright laws and patent filing is presented.

Concepts of DevOps, collaboration between IT, marketing, innovators and external partners is covered too.

3. Writing project proposals, memorandum of understanding (MoU), and contracts are demonstrated in this lecture. The project and sales proposal, negotiation, strategies and procedures are explained. Written and digital/electronic contract modelling is also presented.
4. Document preparation for bookkeeping, accounting and financial statements are presented in this lecture. Methods for keeping journal notes, bookkeeping, accounting policies and procedures are also explained. Small business accounts receivables, payables and inventory control management is explained with the relevant software packages to be used. Financial, management, tax, and project accounting, financial reporting (Income statement, balance sheet and cash flow statement) and financial performance measurement parameters are explained.
5. Understanding of the business law and tax laws are elementary for small business founders. Important recommendations for avoiding racial and sex discrimination problems are presented. The US and EU tax laws are briefly outlined. The learner is required to perform independent comparative study of the local laws and outline all parallels between the US and EU laws, as well as possible differences.

Investor protection, public financial reporting laws (e.g., US Sarbanes-Oxley Act of 2002) are discussed.

6. Marketing and sales management using Customer Relations Management (CRM) and customer experience are main topics of this lecture. Creative multimedia free press and the social media marketing approach to projecting positive presence of the new business and new product or service are demonstrated with examples. Local and global market analysis and predictions using data analytics and sales forecasting methods are explained.

7. As a continuation of the previous lecture, low cost and professional ways of creating an online presence are presented in this lecture. Starting an online presence, the question of whether this should be done either on your own or by hiring a professional service is presented and various options are proposed and discussed. Integrating an accounting system with the online shop design is demonstrated. Options for setting up an e-business using a private infrastructure or setting up an e-business in the public cloud are compared. In addition, pricing as a key factor of successful marketing and online presence is covered too
8. Fundraising, selling shares, selling bonds, taking a loan and investor relations as important issues are elaborated on in this lecture. Writing a business plan, preparing financial reports, and filing for a bank loan or issuing bonds offering is discussed. Hedging against creditors and capitalisation positioning as defensive financial strategic activities in a business organisation of any size are presented.
9. Going public is a question that a growing business may be faced with at a certain point in time. Business laws related to the publicly traded corporations are discussed. The initial public offering, preparations, timing and pricing of the business shares is explained. Business exit strategy and operational transformation problems are presented too.
10. Common pitfalls and errors of early failing start-ups are the main problems elaborated upon in this lecture. Overambitious ungrounded costly marketing is explained as a trap that many capital rich companies fall into. Neglecting and breaking relationships with the employees and with the existing clients, as a common mistake in declining sales trends are presented. Extending large loans and uncontrolled speculative borrowing as a problem to deal with is also presented.

## Assessment Criteria



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| Learning Outcomes                                                                                                                                        | Assessment Criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Upon completion of this study unit, the learner will be able to:                                                                                         | Upon completion of this study unit, the learner can:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 1. Understand the procedure of legally establishing a business operation with liability and tax implications involved with the different business forms. | 1.1 Itemise defining characteristics of the Doing-Business-As (DBA), sole proprietorship, Limited Liability corporation (LLC), and a full corporation.<br>1.2 Determine how state and local (e.g., municipal) governments treat each of the business establishment options.<br>1.3 Determine how to register a new business.<br>1.4 Produce basic business bylaw rules.<br>1.5 Propose to an artwork professional, or select ready-made design of a logo, letterhead, invoice/receipt form, envelopes, and business seal.<br>1.6 Establish a business bank account.<br>1.7 Write a formal business letter.<br>1.8 Perform research and document what the attributes of the satisfied employee are and how to minimise an excessive employee turnover rate. |
| 2. Understand the basic process of market bound innovation and how to creatively take a product or service and transform it into a successful business.  | 2.1 Analyse three cases of successful businesses and explain why the market responded positively to their products.<br>2.2 Explain how strategic innovation that enhances customer freedoms (e.g., freedom of choice, freedom of mobility and communication, freedom of not waiting but getting instant information, etc.) and relevant new product make lead to a successful business.<br>2.3 Produce a manual for an inventor of where and how to apply for patent protection and how to read an existing patent describing document.<br>2.4 Compare different pricing strategies.                                                                                                                                                                       |
| 3. Manage projects, create a sale and realise all steps necessary to be profitable in business.                                                          | 3.1 Write a project proposal.<br>3.2 Prepare a Memorandum of Understanding (MoU).<br>3.3 Explain digital contract and digital watermark features.<br>3.4 Discuss how a complex software project that is to be ready for the market as early as possible is to be handled.<br>3.5 Use data about existing shortage or lack of some product or service and potential market interest and calibrate potential customer, and properly behave during and after the negotiations.                                                                                                                                                                                                                                                                                |



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| <p>4. Maintain business paper documents required by the government that is sponsoring the business environment.</p>               | <p>4.1 Maintain a general activities log.<br/>4.2 Maintain a daily journal of financial activities.<br/>4.3 Maintain a chart of accounts and general ledger.<br/>4.4 Maintain accounts payable, receivable and inventory control documents.<br/>4.5 Use financial documents for analytic data processing and sales forecasts.<br/>4.6 Interact with the bookkeeper and accountant and make a clear distinction between each other.<br/>4.7 Select between options of using in house MIS, online accounting firm via Web services or have in house accountants use cloud based SaaS.</p>                                                                               |
| <p>5. Examine state and local taxation laws and gain awareness of fair business practices and dangers of negligence problems.</p> | <p>5.1 Compare EU, US and Malta business laws and indicate major differences and parallels.<br/>5.2 Document the given state (e.g., state of Malta) and local (e.g., municipality) taxation laws and build a paper or electronic file containing relevant data.<br/>5.3 Isolate the most important financial performance reports and success indicators.<br/>5.4 Specify all financial reports required by the taxation authorities.</p>                                                                                                                                                                                                                              |
| <p>6. Plan effective low-cost marketing and promotion campaigns.</p>                                                              | <p>6.1 Define and design basic architecture diagram of a Customer Relations Management (CRM) system.<br/>6.2 Perform research and document the attributes of a satisfied customer.<br/>6.3 Evaluate all affordable marketing options and rank them.<br/>6.4 Design digital marketing and real-world marketing strategies.<br/>6.5 Produce a plan on how to establish a low-cost and effective online presence.<br/>6.6 Propose web-based automated billing and order tracking procedures of the online shop and design an interface to the accounting software system, e.g., recording/journaling sales, accounts receivables recording, tracking inventory, etc.</p> |
| <p>7. Produce a business plan, plan capitalisation fundraising, recruit investors, sell stock or bonds.</p>                       | <p>7.1 Write an effective business plan backed by appropriate market analysis and previous financial statements.<br/>7.2 Make a decision on capitalisation strategy.<br/>7.3 Establish share prices that may be attractive to investors and profitable for the business.<br/>7.4 Design a plan that takes into account the taking of a bank loan or the offering of bonds for sale.<br/>7.5 Develop management structure policies and investor relationship policies.<br/>7.6 Design a plan of how and when to go public.</p>                                                                                                                                         |





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|                                                                                                                                                                                       | 7.7 Design a strategy of how to hedge against creditors, in case that business goes through unfavourable periods.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| 8. Understand the common errors made by the new and long-time existing business, with recommendations on how to approach starting a business while minimising the chances of failure. | <p>8.1 Study parallel experiences of similar business establishments and compare findings to learn about the good and bad strategic moves made.</p> <p>8.2 Consult with those that have previously started a business and failed</p> <p>8.3 Monitor a CRM system as frequently as possible, introduce continuously necessary measures needed to avoid loss of an existing customer.</p> <p>8.4 Use NodeJS and JavaScript (e.g., 3D framework) or alternative software engineering tools to generate real time compact charting reports needed to support rapid decision making process.</p> <p>8.5 Propose a business, not a cyber, attack detection (e.g., an intrusion attack by a disgruntled employee, or external attack by a new player in the market) solution based on business (e.g., accounting data, marketing data, media reports data, various data feed sources available as Web services) data collected.</p> |

## Assessment Methodology

| Assessment Criteria Covered  | Assessment Scenario                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Assessment Method                                                                                                                                                                                  | Grading Info (optional)                                                                              |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| 1.1, 1.2, 1.3, 1.4, 1.5, 1.6 | <p>Write a preliminary plan to start a business, selecting business forms and explaining the choices made.</p> <p>Describe local business registration procedures.</p> <p>Use MS Excel or Google Docs to design and implement or customise an existing checkbook record management spreadsheet and bank line of credit account management sheet.</p> <p>Describe bank requirements for a new business and bank account establishment.</p> <p>Design all hypothetical stationary letters.</p> | <p>Review of the learner's work results and documented report with screenshots.</p> <p>Review learner's comments and explanations of meaning of each portion of their report. (Weighted at 8%)</p> | <p>Proper assessment criteria report earns</p> $2 \times 1 + 2 + 2 \times 1 + 2 = 8 \text{ points.}$ |



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*"Investing in human capital to create more opportunities and promote the well-being of society"*  
 Project part-financed by the European Social Fund  
 Co-financing rate: 80% European Union; 20% National Funds





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for Malta  
2014-2020



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|                                   | Write six different business letters following US, EU and local standards, (two letters for each standard).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                            |                                                               |
| 2.1, 2.2, 2.3, 2.4                | Describe how innovations can be discovered by accident and how some may be a result of the well-grounded strategic approach, (an honest dream). Study the success history of Apple, Microsoft and Dell and describe where, when and how their founders were innovative.<br>Prepare a hypothetical patent application form and find out what the local, EU and international patent filing fees are.<br>Describe the difference between the pricing strategy of luxury (e.g., tourist resort packages, high end cars, jewellery, etc), high ticket items (e.g., furniture, a house, and so on) and normal consumable products (e.g., gasoline, food, clothes, etc.). | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 8%)        | Each matched assessment criteria earns 4x2=8 points           |
| 3.1, 3.2, 3.3, 3.4, 3.5           | Write a hypothetical project proposal itemising costs and schedules of payments and deliverables.<br>Compare existing project management approaches in the fields of software and electronics.<br>Write, or customise, three MoU documents relating to hypothetical B2B agreements.<br>design your own MS Excel or equivalent software, scrum and sprint management spreadsheets based on studies of existing spreadsheets.<br>Describe the difference between the potential customer and the calibrated lead.                                                                                                                                                      | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)        | Each matched assessment criteria earns 2x2+3x1= 7 points      |
| 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7 | Design a financial journal MS Excel (or equivalent software) spreadsheet.<br>Design a chart of accounts for a small business.<br>Describe the use and benefits of the general ledger.<br>Describe different financial statements that an accounting system can                                                                                                                                                                                                                                                                                                                                                                                                      | Review of the written document and grade matching portions of the document with the learning objectives. (Weighted at 10%) | Maximal matched assessment criteria earns total 5x2=10 points |



Operational Programme II – European Structural and Investment Funds 2014-2020  
“Investing in human capital to create more opportunities and promote the well-being of society”  
Project part-financed by the European Social Fund  
Co-financing rate: 80% European Union; 20% National Funds





EU funds  
for Malta  
2014-2020



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TECHNOLOGY AND  
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|                    | periodically produce.<br>Find free-of-charge, install and configure a small business accounting software online or on the PC.                                                                                                                                                                                       |                                                                                                                                                |                                                                                 |
| 5.1, 5.2, 5.3, 5.4 | Produce all state and local taxation forms.<br>Explain all fields in the LLC taxation forms.<br>Compare US, EU and Maltese taxation laws for an LLC.<br>Present samples of LLC business financial statements required by the various taxation authorities.                                                          | Review of the written document and grade matching portions of the document with the learning objectives. (Weighted at 10%)                     | Maximal matched assessment criteria earns $2 \times 2 + 2 \times 3 = 10$ points |
| 1.3, 6.1, 6.2, 6.3 | Describe a good and bad marketing approach.<br>Specify digital marketing options that small business may have.<br>Specify how to apply for a bank loan, line of credit and how to sell stocks or private bonds.                                                                                                     | Review of the written document and matching portions of the document with the learning objectives. (Weighted at 7%)                            | Maximal matched assessment criteria earns $2 + 3 + 2 = 7$ points                |
| Project            | Use appropriate software tools to produce a business plan for the hypothetical new business.<br>Produce internal business bylaws, document all of the rules in an itemised form that the business will follow, and describe the line of business.<br>Design a graphical image of the logo, letterhead and the seal. | Review of the written project report document and matching portions of the document with the learning assignment objectives. (Weighted at 15%) | Maximal matched assessment criteria earns 15 points                             |
| Midterm test       | Answer the list of 15 questions demonstrating understanding of the relevant terminology and concepts.                                                                                                                                                                                                               | Review questions answered and matching portions of the document with the learning objectives. (Weighted at 15%)                                | Each question properly answered earns 1 point, (Maximum is 15 points)           |
| Final test         | Answer the list of 20 questions demonstrating understanding of the relevant terminology and concepts.                                                                                                                                                                                                               | Review questions answered and matching portions of the document with the learning objectives. (Weighted at 20%)                                | Each question properly answered earns 1 point, (Maximum is 20 points)           |

