FUTURE NETWORKS ACADEMY

Future Networks Academy
Training Development Toolkit

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Introduction

Future Networks Academy (FNA) is an Erasmus+ project that aims at democratizing access to the latest technology in the field of future networks, with a particular focus on 5G and beyond.

There are 6 partner universities in this project: The University of Lorraine in France, Aalto University in Finland, the University of Luxembourg, Delft University of Technology in the Netherlands, Technical University of Madrid in Spain and Polytechnic University of Milan in Italy.

The FNA project intends to develop and implement training schemes for a broad range of stakeholders, including students, researchers, teachers, businesses, decision-makers, and citizens, targeting 4 challenges linked to the development and deployment of new networks:

- 5G for a Competitive EU Industry
- 5G Network for a Sovereign EU
- 5G for Innovators
- Trust in 5G

This toolkit is designed to be a valuable resource for educators and trainers. Its primary purpose is to assist them in developing and delivering tailored training programs that align with the evolving demands of the field. It provides a framework and practical recommendations for creating courses that effectively meet the needs of learners. Our recommendations are based on insights gained from a comprehensive market analysis conducted during the project.

Within this toolkit, you will find guidelines for creating engaging educational experiences, along with methods for evaluating the effectiveness of your training activities and gathering valuable feedback. These components are crucial for ensuring continuous improvement in your educational offerings.

Our ultimate aim is to empower educators to inspire and equip network specialists and enthusiasts, providing them with the essential skills required to excel in this dynamic field. Through this initiative, we hope to contribute to the advancement of knowledge, innovation, and expertise in the realm of future networks.

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Summary of Survey Analysis

The FNA Consortium's survey, aimed at understanding expectations and training needs in the field of future networks, specifically focusing on 5G technology, has provided valuable insights from a broad demographic spectrum of professionals, students, researchers, and policymakers. Distributed electronically across various platforms for maximum reach, the survey attracted 130 responses, illustrating a keen interest across four main training areas envisioned by the FNA.

Key Findings:

Demographics: With a 40% participation from industry professionals, 30% from students, 20% from researchers and educators, and 10% from policymakers/decision-makers, the survey reveals a significant interest in 5G technology across different sectors. A balanced gender distribution and diverse professional affiliations highlight the inclusive nature of the survey.

Geographical Distribution: Participants spanned various countries (France 26.87%; USA 16.42%; Malaysia 10.45%; Finland 7.46%; Canada 7.46%; Ireland 7.46%, Kosovo 4.48%, Japan 4.48% and others), though 10.45% of respondents preferred anonymity regarding their location and gender, slightly impacting the comprehensiveness of the data.

Satisfaction and Preferences: A high level of satisfaction with the survey suggests its relevance and effective design. Participants expressed a preference for adaptive and inclusive assessment formats, underscoring the need for flexible, personalized learning experiences that respect diverse educational backgrounds.

Recommendations:

- Integrate into training curriculum the introductory sessions tailored to different knowledge levels to ensure foundational understanding of all learners.
- Create specialized training modules that delve into practical applications of 5G, highlighting sector-specific benefits and challenges.
- Offer flexible training schemes, including a mix of online, self-paced, and hands-on workshops, to cater to diverse learning preferences and schedules.
- Implement a feedback and continuous improvement process to refine and adapt training content based on participant feedback.
- Enhance representativeness by reaching out to underrepresented groups, ensuring diversity in learning environments and perspectives.
- Communicate impacts of training programs to stakeholders, showcasing tangible benefits and successes to motivate engagement and support.

The survey's findings emphasize the varied interest and expectations regarding 5G technology, highlighting the importance of developing flexible, inclusive training programs. The feedback collected will aim to guide educators in tailoring their training strategies, ensuring they effectively meet the needs of a diverse audience and contribute to the broader adoption and optimization of 5G technology across various sectors.

It's essential to acknowledge that some survey responses may not comprehensively represent the opinions or needs of all members within each target group. This report provides an initial overview based on available data. For a more in-depth analysis, FNA has also assessed existing training offerings to identify market gaps.

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Summary of Training Offers Analysis

As we navigate the transition towards 5G and anticipate the advent of 6G, the landscape of technology usage is poised for significant transformation. The FNA project has conducted a review of current training programs in Europe dedicated to these emerging technologies. Our objective was to assess the existing educational landscape within the telecommunications sector, identify existing gaps, and explore how the FNA project can contribute to bridging these gaps, ensuring a comprehensive and learner-centric approach to education in this rapidly evolving field.

Our benchmarking efforts focused on six European countries - Germany, France, Finland, Spain, Luxembourg, and the Netherlands - selected for their leadership in future networks technology and education. This provided a representative overview of the training landscape across Europe. Our findings reveal a strong emphasis on technical skills related to telecommunications, cybersecurity, and the Internet of Things (IoT) across the board. However, there is a discernible need for greater flexibility within these programs to accommodate a broader spectrum of learners and professionals.

In response, the FNA project offers some recommendations valuable for development of training solutions tailored to meet the varied needs of different learner groups. This entails a consideration of diverse learning preferences, content requirements, and time availability for training. It is recommended to introduce short, targeted workshops for professionals, and as more comprehensive courses for students and life-long learners seeking an in-depth understanding of the subject matter.

In summary, our benchmarking results underline the importance of adaptable, learner-focused training programs in the field of telecommunications and future networks. Colleagues developing their own training initiatives are encouraged to integrate flexibility, diversity in learning modalities, and a forward-looking curriculum into their programs.

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Training Development Recommendations

We have formulated recommendations for the development of five training programs covering various topics, including:

- 5G Network for Industry 4.0
- 5G Network Security: From Fundamentals to Advanced Solutions
- 5G/6G Networks for a Sovereign EU
- Cross-platform app Development in Flutter
- 5G Network and Cybersecurity

These recommendations are not universal solutions but instead flexible guidelines intended to inspire and assist in the development of training programs in the field of network technologies and 5G.

The provided training titles, descriptions, and other essential details can be adapted and customized to best suit the unique needs, preferences, and objectives of learners. Expertise and creativity can be incorporated to craft impactful training experiences that align with the specific context and goals of educational initiatives.

In the pursuit of promoting gender balance and equality within training programs, it is recommended to emphasize the importance of equal representation of diverse gender identities in the selection and enrollment processes. While merit remains the primary criterion for admission, prioritizing gender diversity can enrich the learning environment and promote inclusivity. Furthermore, actively involving accomplished female speakers in training initiatives is encouraged. Their presence not only serves as inspiring role models but also fosters a culture of diversity and inclusion, motivating individuals from all backgrounds to participate and contribute to the advancement of their respective fields.

Training Development Recommendations: 5G Network for Industry 4.0

Brief Description of the Training	This course covers the basic features of 5G mobile network for industrial deployments including the architecture, the main interfaces and functional elements, support for voice services, and the deployment of 5G technology in private networks. Various enabling technologies such Precise Time Protocol (PTP) and Time Sensitive Networking (TSN) will be presented. In addition, 5GLAN and network slicing will be introduced. The course will include hands on experience to deploy and manage private industrial network. A commercial, off the shelf base station would be used for the training and 5G core module to be connected to the base station and few mobile devices used for testing. In this second part of the course, the main aspects related to the writing SIM cards, configuring the devices and

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	connecting industrial switches will be included to show Ethernet and TSN connectivity between 5G and fixed industrial networks.
Intended Audience	The course is designed for students and professionals interested in grasping the nuances of 5G networks, exploring the usage of 5G for industrial private networks.
Audience Needs	To gain hands-on experience in deploying infrastructure while interacting with them through industrial devices.
Training Goals	- Gain knowledge of the fundamentals of 5G mobile network architectures and their evolution towards 6G. - Understand standardization efforts aimed at opening the network to service developers. - Acquire insights of usage of private networks. - Integration of 5G into industrial fixed networks - Master the deployment of a 5G network environment.
Recommended Duration	1 week
Recommended Format	Mixed, the course will be delivered through either in-person or remote classes.
Prerequisites (if any)	- Knowledge in communication networks - ICT Graduate/Master Student or professional - Basic knowledge of Linux environment
Modules Description (courses, topics etc.)	1. Introduction to Mobile Networks. From 2G till 5G 2. Architecture of 5G Mobile Netwoks 3. Services in 5G: a. Voice over NR 4. Introduction to Industrial features in 5G : 5GLAN, TSN 5. Ihdustrial protocols for industrial deployments : PTP 6. Laboratory Sessions a. Set-up of a 5G Platform i. Requirements ii. Identification of Functional Blocks and Interactions iii. Write SIM cards iv. Register user profile to 5G system v. A simple example vi. Capture traffic based on Wireshark b. Industrial deployment i. Connect TSN devices to 5G core ii. Collect PTP messages
Assessment Methods for Learners	Assessment will be based on written and observational (lab-based) assessments.

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Certification (if applicable)	Certificate of Completion upon successful completion of the course
Study Materials/Equipment Required	Personal computer
Preparatory Materials for Learners (if any)	No specific preparation required.
Training Evaluation/Feedback Methods	- Post-training survey to gauge participant satisfaction and areas of improvement. - Follow-up interviews or surveys to assess long-term impact and applicability.

Training Development Recommendations:

Network Security: From Fundamentals to Advanced Solutions

Brief Description of the Training	This course aims to provide a comprehensive understanding of 5G networks and their security aspects. Through this course, learners will learn the key features, benefits, and challenges of 5G networks. They will also develop an understanding of the key concepts, principles, and challenges of 5G security, such as the threat model, the security architecture, and the security requirements. Furthermore, they will learn about the security and privacy solutions proposed by 3GPP to secure 5G networks, including the authentication framework, encryption, and integrity protection schemes. They will also gain practical experience in setting up, configuring, and testing 5G networks using various tools and platforms, such as network emulators, network simulators, and cloud services. The course will also cover the limitations and challenges of the 3GPP 5G security architecture. The learners will learn about state-of-the-art security and privacy solutions for 5G that go beyond the 3GPP standards. They will also develop skills in performing security analysis and assessment of 5G networks and systems. Finally, the course will cover basic machine-learning security solutions for detecting threats in 5G networks. By the end of this course, the learners will be equipped with the necessary skills to analyze, assess, and secure 5G networks effectively.
Intended Audience	- PhD and Postdoctoral students - Researchers

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Audience Needs	To acquire critical skills and knowledge necessary for understanding, analyzing, and securing 5G networks, enabling learners to address the sophisticated challenges and vulnerabilities associated with the latest advancements in telecommunications technology.
Training Goals	- Understand the key features, benefits, and challenges of 5G networks. - Develop an understanding of the key concepts, principles, and challenges of 5G security, such as the threat model, the security architecture, and the security requirements. - Learn about the security and privacy solutions proposed by 3GPP to secure 5G networks, including the authentication framework, encryption, and integrity protection schemes. - Gain practical experience in setting up, configuring, and testing 5G networks using various tools and platforms, such as network emulators, network simulators, and cloud services. - Learn state-of-the-art security and privacy solutions for 5G that go beyond the 3GPP standards and develop skills in performing security analysis and assessment of 5G networks and systems.
Recommended Duration	4-6 weeks
Recommended Format	Mixed (on-site and online)
Prerequisites (if any)	The course requires a basic understanding of computer networks, security, NFV, SDN, Python programming, and machine learning. - Basic knowledge of computer networks and network security concepts. - Basic Network Function Virtualization (NFV) and Software-defined networking (SDN) - Knowledge of basic programming concepts and experience in programming with Python - Familiarity with fundamental machine-learning concepts
Modules Description (courses, topics etc.)	- Introduction to 5G networks and their architecture - Overview of 5G services and applications - 5G radio access network architecture - Service-based architecture in 5G - 5G data plane and control plane - Data flow management in 5G - Mobility management in 5G - Security and privacy challenges - 3GPP Security and Privacy for 5G networks - State-of-the-art security and privacy solutions beyond the 3GPP standards

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	- Advanced techniques on attack detection in 5G
Assessment Methods for Learners	Labs and mini-projects-based assessments
Certification (if applicable)	Certificate of Completion upon successful completion of the course
Study Materials/Equipment Required	Personal computer
Preparatory Materials for Learners (if any)	No specific preparation required.
Training Evaluation/Feedback Methods	- Post-training survey to gauge participant satisfaction and areas of improvement. - Follow-up interviews or surveys to assess long-term impact and applicability.

Training Development Recommendations: 5G/6G Networks for a Sovereign EU

Brief Description of the Training	This training offers a comprehensive exploration of 5G and 6G networks, emphasizing their significance for the European Union. It covers foundational knowledge, security and privacy concerns, and advanced techniques shaping future networks. The training combines theoretical insights with practical cases, addressing common myths, potential risks, and opportunities in the evolving landscape of wireless communication.
Intended Audience	Policy-makers, funding agencies, political science students, EU citizens, undergraduate students.
Audience Needs	To acquire understanding of basic and advanced concepts in 5G and 6G networks, to gain awareness of security and privacy challenges and insight into EU regulations and their impact on network technologies as well as knowledge of future trends in telecommunications.
Training Goals	- Equip participants with a solid understanding of 5G and 6G networks. - Identify and address security and privacy issues specific to these networks. - Highlight the role and impact of AI and advanced technologies. - Foster an understanding of EU policies and their implications.
Recommended Duration	6 to 8 hours, spanning across one to two days
Recommended Format	Mixed (online and in-person)

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Prerequisites (if any)	The participants should have basic understanding of telecommunications; should be aware of general concepts of data security and privacy.
Modules Description (courses, topics etc.)	The training is composed of 4 lectures: Lecture 1: Basic knowledge of 5G/6G networks and its importance for EU Covering some 'popular' myths and facts. Lecture 2: Security Covering potential security issues of 5G networks (in important/sensitive use cases), impact of advanced AI techniques, esp. the LLM or foundation model Some examples, demonstrations. Lecture 3: Privacy Covering potential privacy issues, esp. those might arise from future joint communication and sensing, which data could be sensed. Covering existing EU Data Protection and Privacy Regulations, such as GDPR. Lecture 4: New techniques, challenges, competitions, and international collaborations Covering new techniques that could be used in future networks & Opportunities for EU; International Collaboration and Standards.
Assessment Methods for Learners	- Quizzes at the end of each lecture. - Practical assignments or case studies. - Participation in discussions and Q&A sessions.
Certification (if applicable)	Certificate of Completion upon successful completion of the course
Study Materials/Equipment Required	Recommended readings (journals, articles, EU regulatory documents). Training slides and lecture notes.
Preparatory Materials for Learners (if any)	- Introductory readings on 5G/6G technology basics. - Articles on EU data protection and privacy regulations. - Case studies on current 5G deployments and challenges.
Training Evaluation/Feedback Methods	- Post-training survey to gauge participant satisfaction and areas of improvement. - Follow-up interviews or surveys to assess long-term impact and applicability.

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Training Development Recommendations: Cross-platform app Development in Flutter

Brief Description of the Training	This course aims to present the basics to create cross-platform applications that can properly exploit next-generation networks. Since Android and iOS are incompatible, cross-platform development is emerging as a viable solution to develop one-size-fits-all solutions. In this context, Flutter is a novel technology proposed by Google to develop this kind of applications and the course aims to provide the basics and guide the participants understand the key elements and develop appropriate applications.
Intended Audience	Any person (students and life-long learners) interested in cross-platform development with Flutter who has a basic knowledge of object-oriented programming.
Audience Needs	To master the fundamentals of Flutter to build sophisticated cross-platform applications that leverage next-generation networks.
Training Goals	Understand the basics of Flutter and start developing complex cross-platform applications
Recommended Duration	20 hours
Recommended Format	A mix of conventional classes (ex-cathedra) and lab activities to touch problems and see solutions in reality
Prerequisites (if any)	Basic understanding of object-oriented programming: for example, basic knowledge of Java or C#
Modules Description (courses, topics etc.)	- Introduction to Flutter - Basics of Graphical user interfaces - Adaptable and multi-device layouts - State management and asynchronous programming - Integration with external services - Summary of advanced topics
Assessment Methods for Learners	Learners develop homework while attending the classes, and produce artifacts which are evaluated at the end of the training.
Certification (if applicable)	Certificate of Completion upon successful completion of the course
Study Materials/Equipment Required	A personal computer or similar device with at least a browser. A computer with a complete installation of Flutter would be a better option.
Preparatory Materials for Learners (if any)	No specific preparation required.

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Training Evaluation/Feedback Methods	- Post-training survey to gauge participant satisfaction and areas of improvement. - Follow-up interviews or surveys to assess long-term impact and applicability.

Training Development Recommendations: Android development for 5G networks

Brief Description of the Training	This course aims to provide a short introduction to app development for Android, that is, it aims to explain how to use Kotlin and Jetpack compose to create modern Android applications. After the initial part, the course will focus on Android 5G, that is, the aspects added starting from Android 11 to deal with 5G network specifically. Besides presenting the main concepts, the course will provide concrete examples, discuss real applications, and challenge students on concrete problems.
Intended Audience	Any category of learners with a basic knowledge of object-oriented programming.
Audience Needs	To get practical skills in exploitation of 5G networks in Android apps.
Training Goals	Understand the basics of Android programming and of the specific aspects related to 5G networks
Recommended Duration	20 hours
Recommended Format	A mix of conventional classes (ex-cathedra) and lab activities to touch problems and see solutions in reality
Prerequisites (if any)	Basic understanding of object-oriented programming: for example, basic knowledge of Java or C#
Modules Description (courses, topics etc.)	- Introduction to Android and Kotlin - Jetpack - Basics of building Android apps - Android 5G - 5G network slicing - Meteredness, 5G detection, Bandwidth estimation -
Assessment Methods for Learners	Participants are supposed to develop homework while attending the classes, and produced artifacts will be evaluated at the end.
Certification (if applicable)	The learners will receive a Certificate of Completion upon successful completion of the course.
Study Materials/Equipment Required	A computer with a working installation of Android and Android studio.
Preparatory Materials for Learners (if any)	Not applicable
Training Evaluation/Feedback Methods	- Post-training survey to gauge participant satisfaction and areas of improvement.

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	- Follow-up interviews or surveys to assess long-term impact and applicability.

Training Development Recommendations: 5G Network and Cybersecurity

Brief Description of the Training	This course covers the fundamental characteristics of 5G mobile network architecture, including the main interfaces and functional elements, support for voice services, and the deployment of 5G technology in private networks. Various enabling technologies that support 5G networks, such as SDN, NFV, MEC, which enable advanced network slicing services, are also introduced in the course. In the second part of the course, the main aspects related to the security of 5G networks is described, including the proposed security architecture and the security mechanisms included in 5G, focusing on the improvements introduced compared to 4G. The course is complemented by a practical section where learners are trained in deploying a 5G environment where attacks are simulated, and Machine Learning (ML) techniques are used for pattern learning and subsequent attack detection.
Intended Audience	The course is designed for students and professionals interested in grasping the nuances of 5G networks, exploring their security aspects, and gaining hands-on experience in deploying infrastructure while interacting with them through cyberattack development.
Audience Needs	To know how to navigate and secure the evolving 5G landscape, ensuring robust architecture and protection against cyber threats with advanced cybersecurity and machine learning techniques.
Training Goals	- Gain knowledge of the fundamentals of 5G mobile network architectures and their evolution towards 6G. - Understand standardization efforts aimed at opening the network to service developers. - Acquire insights into the security aspects defined in 5G networks. - Learn the basics of intrusion detection systems based on Machine Learning (ML). - Master the deployment of a 5G network environment. - Experience the development of scenarios for executing cyberattacks and the design of ML-based detection systems.
Recommended Duration	1 week
Recommended Format	Mixed (in-person and remote classes)

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Prerequisites (if any)	networks and virtualization environments. • Knowledge in communication networks • ICT Graduate/Master Student or professional • Basic knowledge of Linux environment
Modules Description (courses, topics etc.)	7. Introduction to Mobile Networks. From 2G till 5G 8. Architecture of 5G Mobile Netwoks 9. Services in 5G: a. Voice over NR b. Open Gateway API. 10. Introduction to SDN & NFV 11. Cybersecurity on 5G a. 5G Security Architecture: Inheritance and Differences from 4G. b. Security Mechanisms Used in 5G: Authentication, Encryption, Key Exchange, etc. i. Related Protocols and Technologies (EAP, IPSec, TLS, DTLS, OAuth, AES, etc.) ii. Security of 5G Network Virtual Infrastructure (NFV Security, Isolation, VXLAN, etc.) iii. Standardization of Security Systems in 5G iv. NESAS Scheme c. Applicable European and National Regulations (EU Toolbox, RD 7/2022, CCN Regulations, etc.)…. 12. Attack detection based on Machine Learning 13. Laboratory Sessions a. Set-up of a 5G Platform i. Requirements ii. Identification of Functional Blocks and Interactions iii. A simple example iv. Downloading video example v. Capture traffic based on Wireshark b. Cybersecurity attack based on crypto-mining over 5G network i. Set-up of the scenario ii. Machine-Learning algorithms to detect attacks iii. Dataset capture iv. Training and detection phases
Assessment Methods for Learners	Assessment will be based on written and observational (lab-based) assessments.
Certification (if applicable)	The learners will receive a Certificate of Completion upon successful completion of the course.
Study Materials/Equipment Required	A personal computer

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Preparatory Materials for Learners (if any)	No specific preparation required.
Training Evaluation/Feedback Methods	- Post-training survey to gauge participant satisfaction and areas of improvement. - Follow-up interviews or surveys to assess long-term impact and applicability.

Conclusion

In the dynamic landscape of future networks and 5G technology, the importance of customization in training cannot be overstated. This Toolkit has highlighted the diverse needs, preferences, and knowledge levels of different audience segments, ranging from industry professionals to students, researchers, and policymakers. Understanding the audience's needs and knowledge gaps is the first step toward delivering effective training programs that resonate with learners and drive meaningful impact.

We hope that our Toolkit can serve as the foundation for educators, trainers, and institutions to craft their training programs in the field. However, it is essential to recognize that universal solutions are not sufficient in this domain. Instead, flexibility and adaptability are the cornerstones of effective training.

To further enrich this Toolkit, we are committed to enhancing it with case studies drawn from the evaluations and feedback provided by learners during our planned training activities.

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3. "SDN & NFV in 5G: Advancements and challenges", C. Bouras, A. Kollia and A. Papazois, 2017 20th Conference on Innovations in Clouds, Internet and Networks (ICIN), Paris, 2017.
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    b. Virtualized RAN, Centralized RAN and Open RAN
    c. Cloud RAN
    d. 5G Core Fundamentals
    e. Introduction to SDN (Software-defined Networking)
    f. What is NFV?
    g. 5G NSA vs SA
    h. From 5G-Advance to 6G.
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