(Softwarized and Programmable Networks)

Unit 1: Introduction to Softwarized and Programmable Networks.
- Brief introduction to the key concepts of Softwarized and Programmable Networks.
- Motivation to SDN, the SDN 4 pillars. Network Programmability (from OpenFlow to programmatic interfaces (NETCONF, YANG), to P4).
- Industry related interfaces (T-API, IETF), whiteboxes.
- Applicability of SDN, SDN control over packet, optics, micro-wave networks. TIP MUST project.

Unit 2: OpenFlow: Introduction.
- Architecture and generalized forwarding (forwarding table, actions and match rules, etc.).
- OpenFlow 1.5 Specification. Protocol operation. Applications and scenarios for the use of OpenFlow.
- OF-CONFIG and NETCONF. Limitations of OpenFlow.

Unit 3: OpenFlow Controllers & Related Tools.
- SDN software switches: Open vSwitch (OVS) and CPqD/BOFUSS
- SDN hardware switches.
- Architecture of OpenFlow Controllers. Overview of different open source SDN controllers and frameworks (Ryu, OpenDaylight, ONOS). Other SDN frameworks (including commercial ones). Intent framework.
- Use cases (CORD) and reference designs by ONF (NG-SDN, COMAC, etc.).
- Testing with Mininet.
- Related trends: P4, STRATUM, PINS, PRONTO, Anuket, µONOS.

Unit 4: Related programming interfaces and utilities.
- Flowbricks.
- Network Hypervisors (e.g., CISCO OverDrive).
- Debugging SDN: ndb.
- Related projects: Pyretic,

- Network Modelling Language, NetIDE

Unit 5: Advance network programmability
- SDN Composition,
- Service Chaining,
- Network Hypervisors,
- Network Emulation,
- Network Slicing,
- Service Orchestration,
- Debugging and Verifying SDN,
- Network Overlays,
- SD-WAN,
- vCPEs,
- P4 language

Unit 6: Relevant Standardisation efforts.
- IETF.
- ONF,
- MEF.
- Open Source projects. NetConf, YANG, ACTN and Segment Routing