Contribution to Telecom Standardization

IEEE, TSDSI and 3GPP
Contributions to IEEE Standards in 5G

- Our group has initiated a new IEEE standard on Software Defined Networking in 5G
  - IEEE P1930.1: Recommended Practice for Software Defined Networking (SDN) based Middleware for Control and Management of Wireless Networks

- We have also pioneered the concept of Frugal 5G for Rural Broadband
  - IEEE P 2061: Architecture for Low Mobility Energy Efficient Network for Affordable Broadband Access
Standard Development for SDN based Wireless Networks

- **IEEE Project 1930.1 (IEEE P1930.1)**
  - Standard Development Project initiated under IEEE Communications Society by our group @ IIT Bombay

- **IEEE Working Group**
  - SDN-MCM - SDN based Middleware for Control and Management of Networks

- **Project**: Recommended Practice for Software Defined Networking based Middleware for Control & Management of Wireless Networks

- **Project Goal**: To define an SDN based Middleware for Management & Control of Wireless Access Networks
  - IEEE 802.11 based Wireless Local Area Networks
  - IEEE 802.22 based Wireless Regional Area Networks
  - 3GPP Access Networks

- **IIT Bombay playing a very active role in standard development**
Emerging Mobile Network Architecture

- Increased Network Densification
- Multi-RAT Networks - Presence of 3GPP & Non-3GPP Access (e.g. Wi-Fi)
- Unified 5G Core
- Common Interface towards Core for Access Networks
- Wi-Fi an Important Access Technology for 5G

Fragmented Decision Making in RAN
Need for Unified Control of Multi-RAT RAN
Dual Connectivity
- UE Connects to two BSs (eNB/gNB/AP)

UE’s Primary Signalling Connection with a single eNB/gNB

Radio resources in each BS under the control of RRC at each eNB/gNB
- Extensive coordination between eNBs/gNBs

Subtle differences in DC mechanism across RATs
- LTE-LTE DC, MR-DC, LTE-WLAN Aggregation (LWA)
- Brings higher complexity
IEEE P1930.1 - Unified Multi-RAT RAN

- **SDN Middleware**
  - Abstract Information Model of underlying RAN
  - Through Virtual Network Entities

- **SDN Controller**
  - Control and Management of the Access Network

- **Management and Orchestration Entity**
  - To Orchestrate & Manage the SDN Middleware over RAN Infrastructure

- **Radio Access Network Infrastructure**
  - Access Points, Base Stations, Network Interworking Functions
IEEE P1930.1 - SDN Middleware Interfaces

- Northbound Interface of the Middleware
  - Interface between the virtual entities and the Controller
  - NETCONF for Management (Configuration) and Openflow for Control

- Southbound Interface of the Middleware
  - Interface between the physical infrastructure, e.g., AP and the Middleware
  - Can be based on vendor specific or standard protocols
    - Control And Provisioning of Wireless Access Points (CAPWAP)
    - Lightweight Access Point Protocol (LWAPP)
    - SNMP
    - OpenFlow
    - NETCONF

- Middleware maps the Southbound Interface with the Northbound Interface
IEEE P1930.1 - Key Principles

- Unified Controller
- Modular, Re-usable Multiple Data Plane Functions
  - Managed/Controlled by Controller
- Virtualization of Data Plane through SDN Middleware
  - Abstract Information Model for the Controller
- Unified Interworking with Core Network
  - RAT Agnostic Interworking with Core
  - In case of 5G - Comprise of N2/N3 Interface Functions
- Separation of UE Control from Network Control
  - UE Control
    - Responsible for UE Management/Control
    - Uses RRC Protocol in LTE/5G NR RAN
  - Network Control
    - Control/Management of RAN Data Plane
IEEE P1930.1 - Modular Data Plane

- Modular Data Plane Functions, Examples

- ...

- Radio Tx/Rx Function (BS)
  - May Include Physical Layer, MAC Layer etc.

- Security Function (SF)
  - Encryption and Integrity Protection

- Optimization Function (OptF)
  - IP Header Compression etc.

- RAN Adaptation Function (AdpF)
  - Link Control, ARQ etc.

- Interworking Function (IWF)
  - Interworking with Core
  - In case of 5G - Comprise of N2/N3 Interface Functions

- ...

- ...
There may be additional RAN Functions, not shown here

Virtual Functions may be used for only control and management purposes by the unified Multi-RAT Controller

VFs may have some data processing functionality also
Frugal 5G Networks - IEEE P2061
Standard Development for Rural Broadband Connectivity

- **IEEE Project 2061 (IEEE P2061)**
  - Standard Development Project initiated under IEEE Communications Society by our group @ IIT Bombay

- **IEEE Working Group**
  - Frugal 5G Networks

- **Project**: Architecture for Low Mobility Energy Efficient Network for Affordable Broadband Access

- **Project Goal**: To specify
  - An Architecture for a Low Mobility and Energy Efficient Network for Affordable Broadband Access to be referred as the “Frugal 5G Network”
  - The “Frugal 5G Network” comprises of
    - A Wireless Middle-mile Network
    - An Access Network
    - The Associated Control and Management Functions

- **IIT Bombay playing a very active role in standard development**
Frugal 5G Networks (IEEE P2061)

Refers to the vision of providing broadband access to rural areas by addressing these requirements and challenges.
IEEE P2061 Network Architecture - Features

- Large Coverage Area
  Cells to provide ubiquitous connectivity

- Small Cells (WiFi Hotspots) as high speed access points

- Wireless Middle Mile Network to backhaul data

- Point to point wireless links to connect the nodes in villages

Diagram:
- Macro BS
- Wireless Middle mile Network
- WLAN
- Ethernet Link
- Wireless link
IEEE P2061 Network Architecture - Features

SDN based unified control -
Efficient service delivery,
Independent Evolution and
Development of control/data
plane entities

Usage of Virtual Network
Functions - makes the system
cost-effective

Intelligence at the edge -
Enables local communication
& reduces resource usage
Other Contributions
Contribution to Other Standards - TSDSI and 3GPP

- TSDSI
  - Enhanced Relay Architecture for 4G/5G Networks

- 3GPP
  - Mission Critical Communication
THANK YOU