Network Intelligentizing for Future 6G Wireless Networks

How AI will Enable Network Intelligentizing?

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Md Arifur Rahman, Senior R&D Engineer, IS-Wireless, Poland
Part I

Network Intelligentizing Aspects on Future 6G Networks
What will be the future 6G network?

*The future 6G network architecture which will cover everywhere with 6G connections.

*Source: https://www.rfwireless-world.com/Terminology/

Smart connectivity of future 6G networks
- Remote radio heads (RRH)
- Drones
- Visible light communications (VLC)
- Base stations (BSs)
- Network equipments mounted on moving things e.g., autonomous smart vehicles

Network architecture of future 6G
- Cell-free smart surfaces with ultra-high frequencies
- Temporary hotspots served by drone mounted BSs
- Network in a spray i.e., Air-duct/Water-duct
- Using cars as fog/edge devices
- Water duct communications
The Vision of AI in Future 6G Networks

Future 6G networks

Technology enablers

- Edge AI
- AI for wireless networks
- AI-empowered applications
- Self-definable networks

Requirements for 6G

- Intelligent connectivity (IC)
- Deep connectivity (DC)
- Ubiquitous connectivity (UC)
- Holographic connectivity (HC)

Requirements for 6G

- AC enabler
- DC enabler
- UC enabler
- HC enabler

Requirements for 6G

- Wisdom connection in the network
- AI-assisted massive connectivity
- Deep sensing for cloud, edge, and computing devices
- Deep learning (AI)
- Ubiquitous connection to cover space, air, ground, and sea
- Ubiquitous intelligence for LIS
- Seamless coverage anywhere using AR/VR
- Holographic radio for PHY layer
Network Intelligentizing Aspects on Future 6G Networks

- On-device distributed learning
- Deep learning concept
- AI solutions in wireless networks
- Big-data era is coming
- Increasing of computing power

- Communications
- Content caching
- Computing capabilities
- Wireless power transfer
- Flexible, adaptive, and intelligent solutions

- Planning and design
- Operation and management of the networks
- Measurement and monitoring
- Radio resource management (RRM)
- Security enhancement

Network intelligentizing aspects on future 6G networks
Part II

AI enabled network revolution
Challenges on the Wireless Communication Industry [1/2]

Massive growth of devices

In 2020, global IoT devices will grow to 50 billion, 6 times more than the device in 2011.

Massive growth of data

- In 2020, 35 EB per month data traffic will be generated as a mobile data traffic
- In 2020, global data amount will increase up to 40 ZB and it is 50 times more than in 2011

*Source: Comp TIA, CISCO*
Challenges on the Wireless Communication Industry [2/2]

The evolution of wireless networks:
- Voice, Data, & Video
- Video Telephony
- Internet surfing
- 3G, W-CDMA, UMTS
- Enhanced 3G
  - Interoperability protocol
  - High speed and IP-based
  - 4G, Mobile IP
- Wireless World Wide Web
  - High speed, high capacity
  - Large broadcasting of data in Gbps
- Tactile/Haptic internet
  - Fully automated driving
  - Industrial internet
  - Digital sensing and reality
  - Distributed intelligence

Network softwarization:
- Traditional network architecture
  - Data plane and control plane are not separated
  - No programmability
  - Global picture unavailability
- Network softwarization
  - Separation of control and data planes (SDN)
  - Network function virtualization (NFV)
  - Cloudification
Importance of intelligentizing the future 6G networks

- Influence advanced wireless communications and mobile computing technologies
- Enable AI-enabled applications at different edge devices of the networks with limited computational capability and energy resources
- Scaling up distributed training and inference over the cloud, network edge, and end devices
- AI-enabled security enhancement
- AI could adaptively adjust and optimize the networks
- Realize fully end-to-end automated network architecture
Roadmap on network intelligentizing

Part III

Roadmap on network intelligentizing
Potential of AI in Future 6G networks

User equipment

RAT

Radio Access Network

Core network

Internet/Cloud

Cellular (4G, 5G, and 6G)

Licensed band (MHz, THz)

Shared

ISM, mmWave

802.11ax (NG-WiFi), 802.11ay (WiGi2)

Other non-cellular

Large-scale intelligent surface

AI for radio access network optimization
- AI-assisted PHY layer
- AI for network/MAC radio resource management

AI for Operation and management of the networks
- Network design and planning
- Critical network management

Core network

High performance computing

6G AI Core

Internet/Cloud

Al-based cloudification

6G AI RAN

vRAN/C-RAN

Small cell

Indoor RRH

MEC server

Outdoor RRH
Application of AI in future 6G networks

AI for PHY layer
- Signal detection, classification, and compression
- Channel encoding and decoding
- AI-assisted positioning, sensing, and localization
- Channel estimation and equalization
- AI compatible edge devices

AI for MAC layer RRM
- User clustering for cell-free smart surfaces with ultra-high frequencies
- Dynamic scheduling of resources
- Adaptive power control
- Interference management

AI for higher layer RRM
- AI-assisted brokering mechanism for RAN slicing
- Slice admission control
- Slice scheduling
- Handover management
- Mobility management

AI for operation and management
- Dynamic network orchestration
- Dynamic slice management
- Control and policy enforcement
- Critical network management
- Measurement and monitoring
- Security enhancement
Open question: How AI will enable network intelligentizing?

- **AI will enable network intelligentizing based on the following aspects:**
  - Real-time conversations amongst the network entities
  - Combination of AI-designed underlying network topologies and AI-driven SDN
  - Intelligent operation and management of the networks
  - AI in RAN to optimize the network resources
  - AI-based mobile applications
  - Intelligent wireless communication
  - Proactive maintenance
Md Arifur Rahman
a.rahman@is-wireless.com
IS-Wireless,
ul. Puławska 45b
05-500 Piaseczno / near Warsaw
Poland

Phone +48 22 123 8297
Mobile: +48 663 268 958
www.is-wireless.com
info@is-wireless.com