Chapter 5. Edge Computing & IoT

Cloud Computing Challenges:

The traditional centralized Cloud Computing is encountering severe challenges:

- High latency,
- Low spectral efficiency (SE), and
- Non-adaptive machine type of communication

Edge devices of the network solve these challenges

Internet of Thing (IoT):

- IoT refers to the interaction and communication between billions of devices that produce and exchange data related to real-world objects (i.e. things).

- IoT introduces new challenges that cannot be adequately addressed by the centralized Cloud Compute architecture, such as:
    - High latency,
    - Capacity constraints,
    - Resource-constrained devices,
    - Uninterrupted services with discontinuous connectivity
    - Enhanced security

- IoT applications generate enormous amounts of data (BigData) by IoT sensors which needs to analyze to determine reactions to events or to extract analytics or statistics.
- Sending all data to the Cloud will require high network bandwidth
    - If you use cloud computing, you'll have challenges like: high latency, low spectral efficiency
    - The solution is Edge Computing

Edge Computing:

- the massive data generated by different kinds of IoT devices can be processed at the network edge instead of transmitting it to the centralized Cloud to solve **bandwidth** and **energy consumption** concerns, So Services could be provided with **faster response** and **greater quality** comparing to Cloud Computing.

- Three typical Edge computing technologies:
    - Cloudlets,
    - Mobile Edge Computing
    - Fog Computing.

- Edge computing systems should integrate with Cloud environments, to create a hybrid Edge-Cloud infrastructure.
- Applications, data, logs, and the like generated at the Edge should be linked back to the Cloud, whether Private or Public.
    - Likewise, resources that exist primarily in the Cloud should be tied back to the Edge, To ensure production continues even if the Cloud disappears for a time.

Edge Characteristics:

- Low Latency, Real Time, Optimized Infrastructure and Rapid Response
- Massive Various Data Storage and Movement, Data Sovereignty
- Enhanced Security and Data Privacy
- Context or Location Awareness, Localization
- Multi-Access Networking across Large-Scale and Small-Size Sites: Unreliable, Limited, High Bandwidth
- Intelligence, Smartness, Autonomy, Zero- Touch, Self-X

IoT, Edge-Computing

- Edge computing-based architecture can be considered for the future loT infrastructure
- Software Defined Networking **(SDN)** and the associated concept of Network Function Virtualization **(NFV)** are proposed as emerging solutions for the future network
- **NFV** enables Edge devices to provide computing services and operate network functions by creating multiple Virtual Machines (VMs).
- Ultra-low latency is identified as one of the major requirements of the fifth generation (5G) Radio Access Networks **(RANs)**

Cloudlets Technology

- Cloudlet is a mobility-enhanced small-scale cloud data center located at the Edge of the internet.
- A Cloudlet is a trusted, resource-rich computer or cluster of computers that is well-connected to the internet and available for use by nearby mobile devices.
- Cloudlets has proposed to support **low-latency** requirements for:
    - resource-intensive
    - interactive mobile applications
- Cloudlets represent the middle tier of the 3-tier hierarchy architecture:
    - Mobile device layer
    - Cloudlet Layer
    - Cloud layer to achieve crisp response time.

Cloudlet: Treated as "data center in a box" running a virtual machine capable of provisioning resources to end devices and users in real time over a WLAN network. The services are Cloudlets are provided over a one-hop access with high bandwidth, thus offering low latency for applications.

Cloud and Cloudlets

- Important differentiators between *Cloud data center* and *Cloudlet*:

1. *Cloudlet* needs to be more agile in their *provisioning* because the association with *highly dynamic mobile devices* with considerable *churn* due to user mobility
2. To support user mobility, *VM handoff technology* needs to be used to seamlessly *migrate the offloaded services* on *the one Cloudlet* to the *another Cloudlet* as a user moves away from the currently associated cloudlet;
3. Since *Cloudlets* are *small data centers distributed geographically*, a mobile device first has to *discover*, *select*, and *associate* with the *appropriate Cloudlet* among multiple candidates before it starts *provisioning*.

MOBILE EDGE COMPUTING (MEC)

Mobile/Multi-access Edge Computing (MEC):

- "To bring computational and storage capacities to the edge of the network within the Radio Access Network to: **Reduce latency and improve context awareness.**
- The MEC nodes or servers are usually co-located with the **Radio Network Controller** or a **macro base-station**.
- The servers run multiple instances of MEC host which has the capabilities to perform computation and storage on a virtualized interface."

Fog Computing: placing some processes and resources at the edge of the Cloud, instead of establishing channels for Cloud storage and utilization.