Intelligent IoE Fog Networking technologies based on ICN

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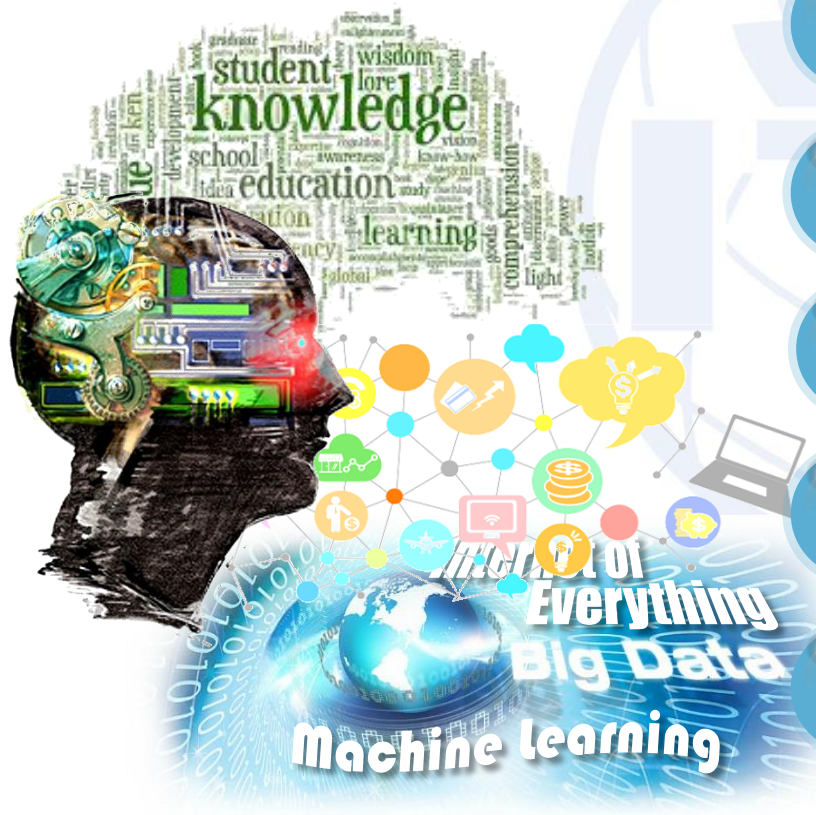
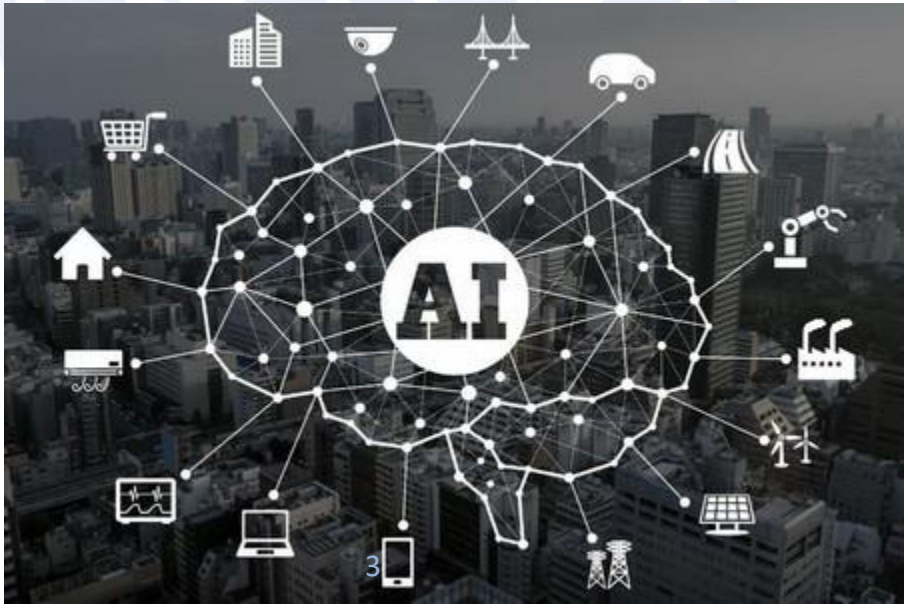
Agenda



1. Introduction
2. Related Work
3. Requirement & Principles
4. Proposed Intelligent Framework
5. Prototype & Applying case
6. Summary

1. Introduction (1/3)

- ***Service aspects***
  - AI service appeared as the core of the 4th industrial revolution
  - Attempts to enter AI service for each service domain
    - AI technology for image recognition, speech recognition, Go, etc. is superior to human
    - AI technology shows good performance even in creative field such as art, music, literature



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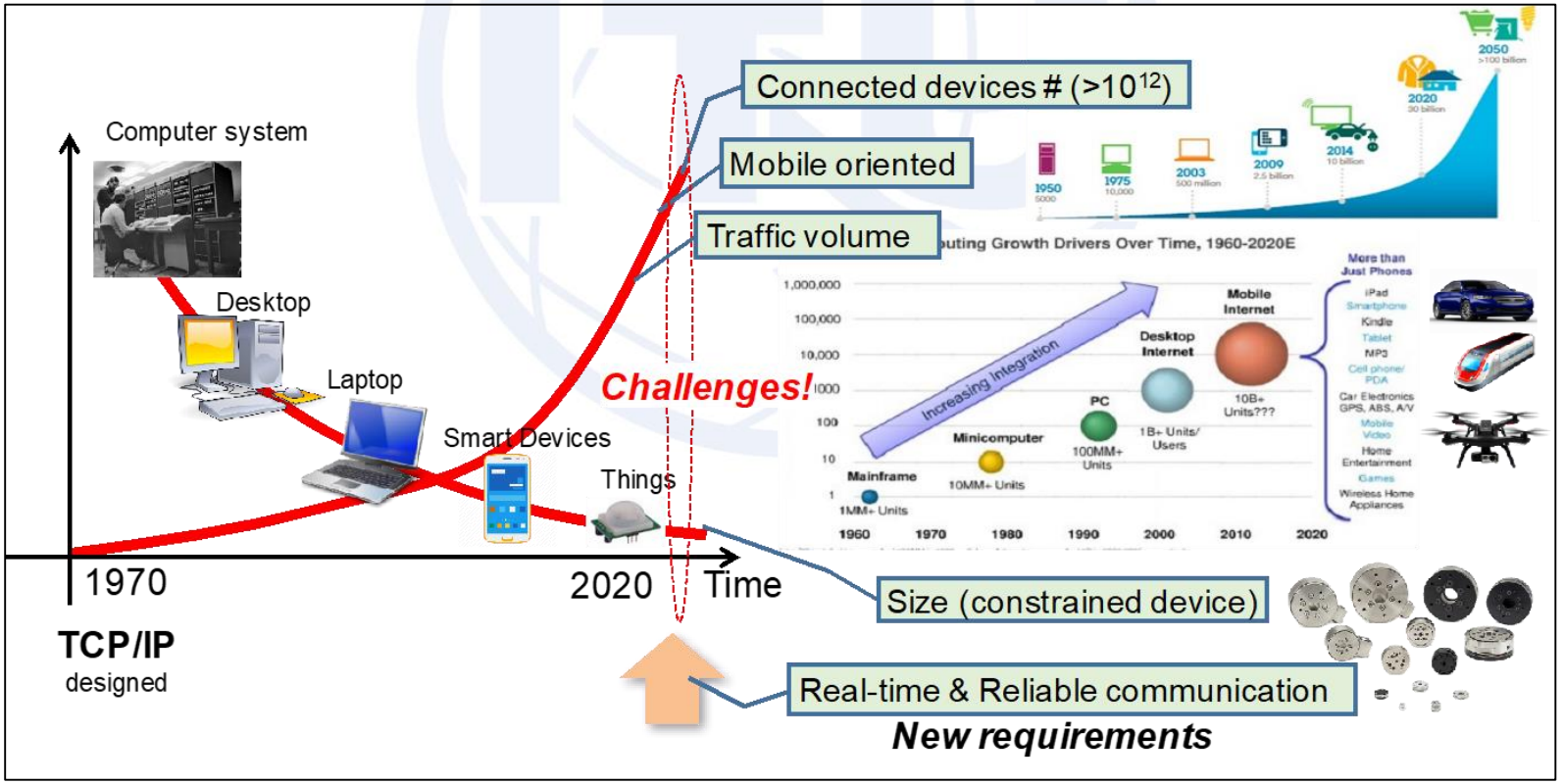
1. Introduction (2/3)

- ***Network aspects***
  - ***Massive devices, Mobile oriented, Massive traffic***
  - ***Constrained device size, Real-time & Reliable comm.***

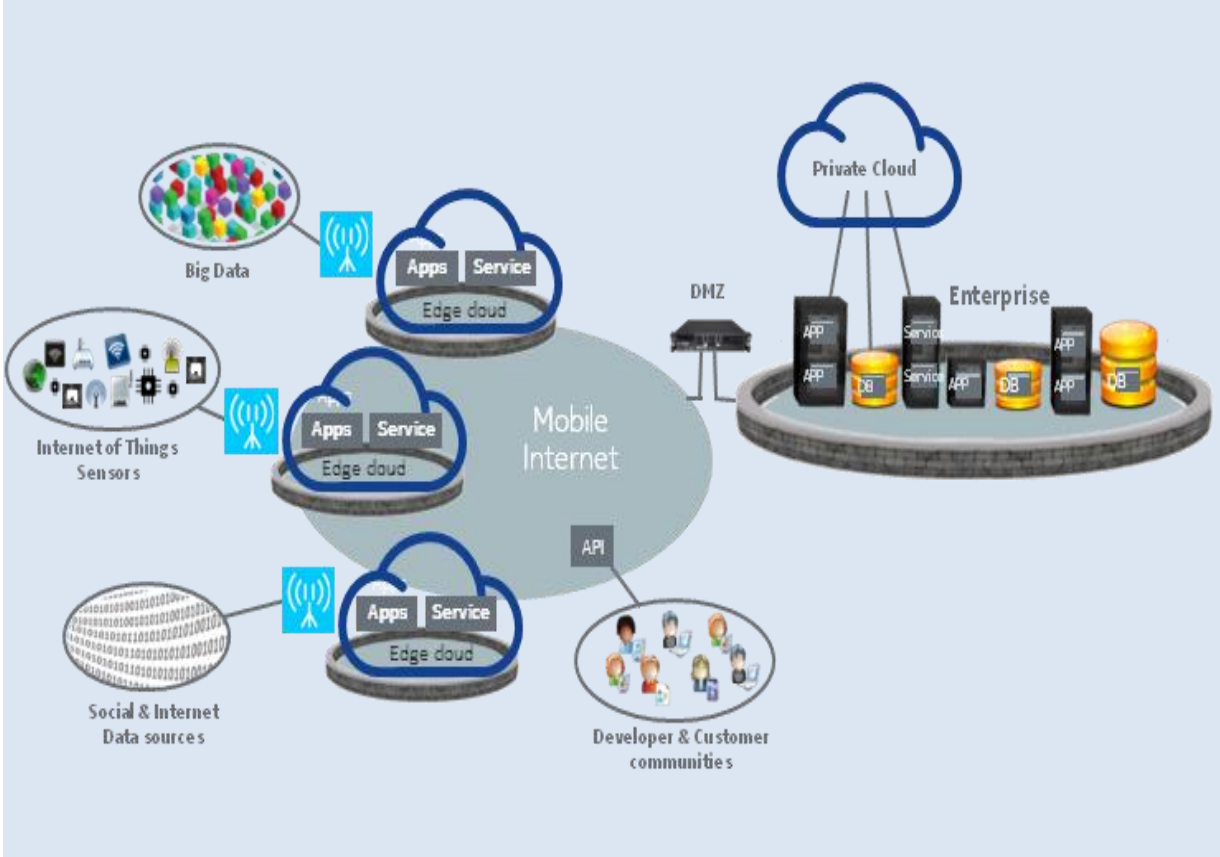


1. Introduction (3/3)

- ***Service + Network aspects***
  - Attempt to apply AI in network domain
  - Try with two perspectives
    - Supporting AI domain services well
      - Fog / Edge computing for data and computing of AI
      - Name based ICN for processing large data at network level
    - Using AI technique itself to improve network performance
      - AI-based network intelligence
      - Intelligent network management, configuration, control, etc

2. Related work – Fog/Edge Computing (1/3)

- ***Why Fog/Edge Computing?***



Cloud-computing at the network edge.

- **Proximity**
- **Ultra-low latency**
- **High bandwidth**
- **Real-time access to access network and context information**
- **Location awareness**

<Ref. ETSI MEC Overview>

2. Related work – Fog/Edge Computing (2/3)

- ***Benefit of Edge/Fog Computing***
  - Quality of Experience
  - Contextualized services
  - Efficient utilization of the Radio and the Network resources
  - Innovative applications and services towards mobile subscribers, enterprises and vertical segments

Real time	Interactive	Analytical	Security and privacy	Distributed

2. Related work – Fog/Edge Computing (3/3)

- ***Edge/Fog computing vs. cloud computing***

CLOUD

Edge/Fog

Smart Things

- **Cloud Data center**
- Exist in Core
- Multiple high-end servers
- Processing and storing an enormous amount of data

- **Edge/Fog computing layer**
- Exist in the edge network
- Comprise of devices
- Process, compute, temporarily store data
- Responsible for sending data to Cloud

- **Smart Things**
- Exist in proprietary network
- Sense or generate data
- Transmit the data to its nearest layer

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2. Related work – ICN (1/3)

- ***Why ICN(Information-Centric Networking)?***
  - The estimated video traffic will reach 79% of the Internet traffic by 2018
  - Content distribution is the primary task for today's Internet
  - Traditional paradigm of communication network is end-to-end, i.e. host-centric
  - End-to-end has many drawbacks when dealing with large scale content distribution, efficiency, security and privacy
  - Paradigm shifts from host-centric to content-centric
    - Content consumer only cares what it is instead of where it is from

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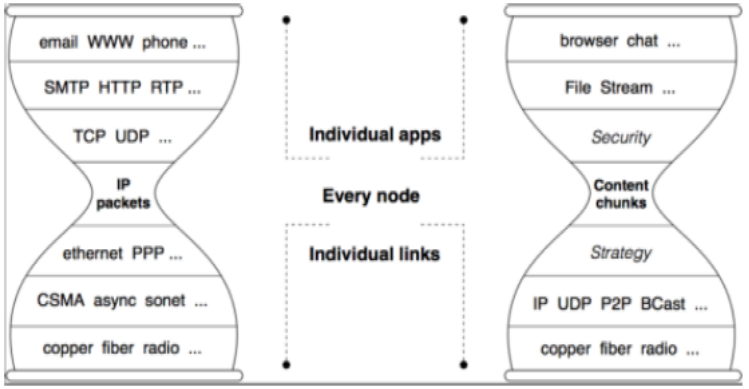
2. Related work – ICN (2/3)

- ***Characteristic of ICN(Information-Centric Networking)***
  - ICN is a clean-slate redesign of the current Internet infrastructure
  - Communication object (CO) is accessed by name
    - CO includes a content, a device, and a service
  - ICN enables in-network caching
    - so that content is distributed in a scalable, cost-efficient and secure manner
  - Reasonable solution for low-latency & massive IoT



"Thin waist of the Internet"

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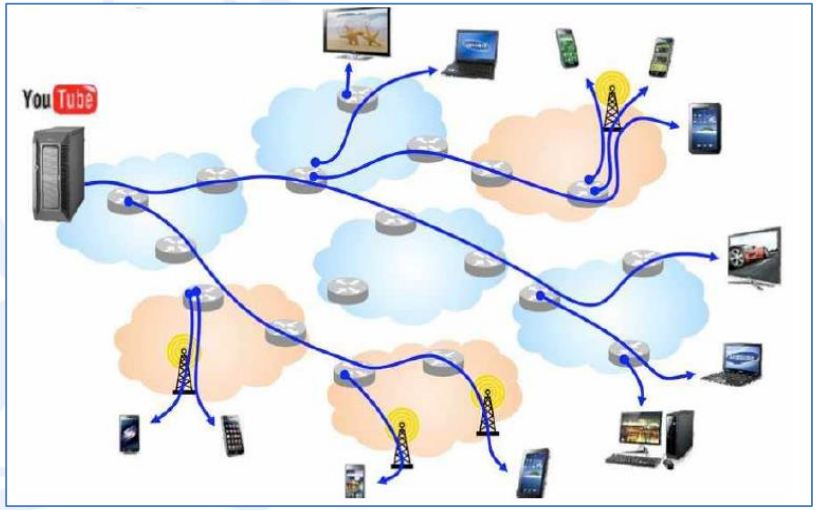
2. Related work – ICN (3/3)

- ***Benefit of ICN(Information-Centric Networking)***

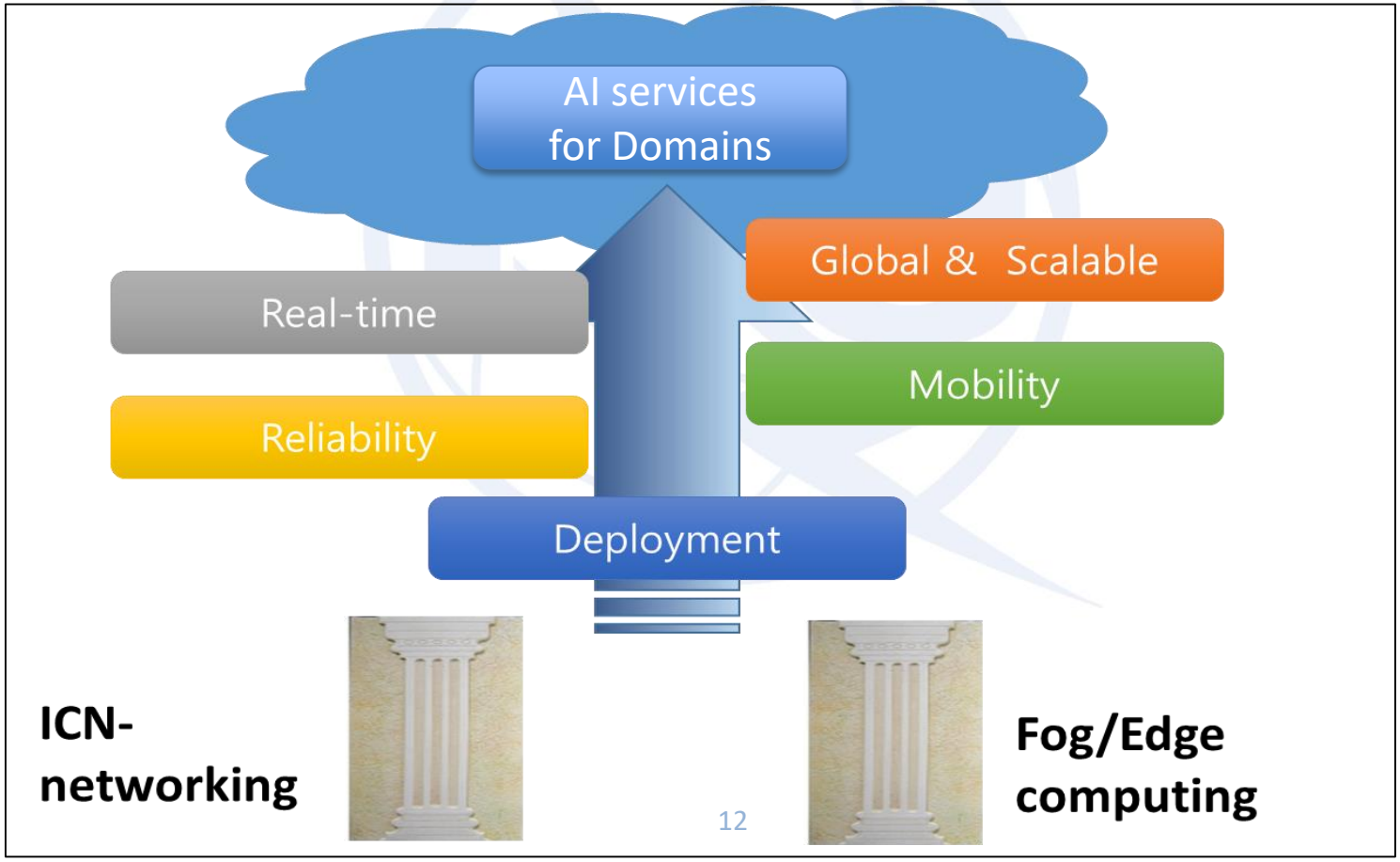
<As Is>
Server bottleneck
with concentrated on contents
in current IP environment



<To Be>
Transfer Content
without Server bottleneck
in ICN environment

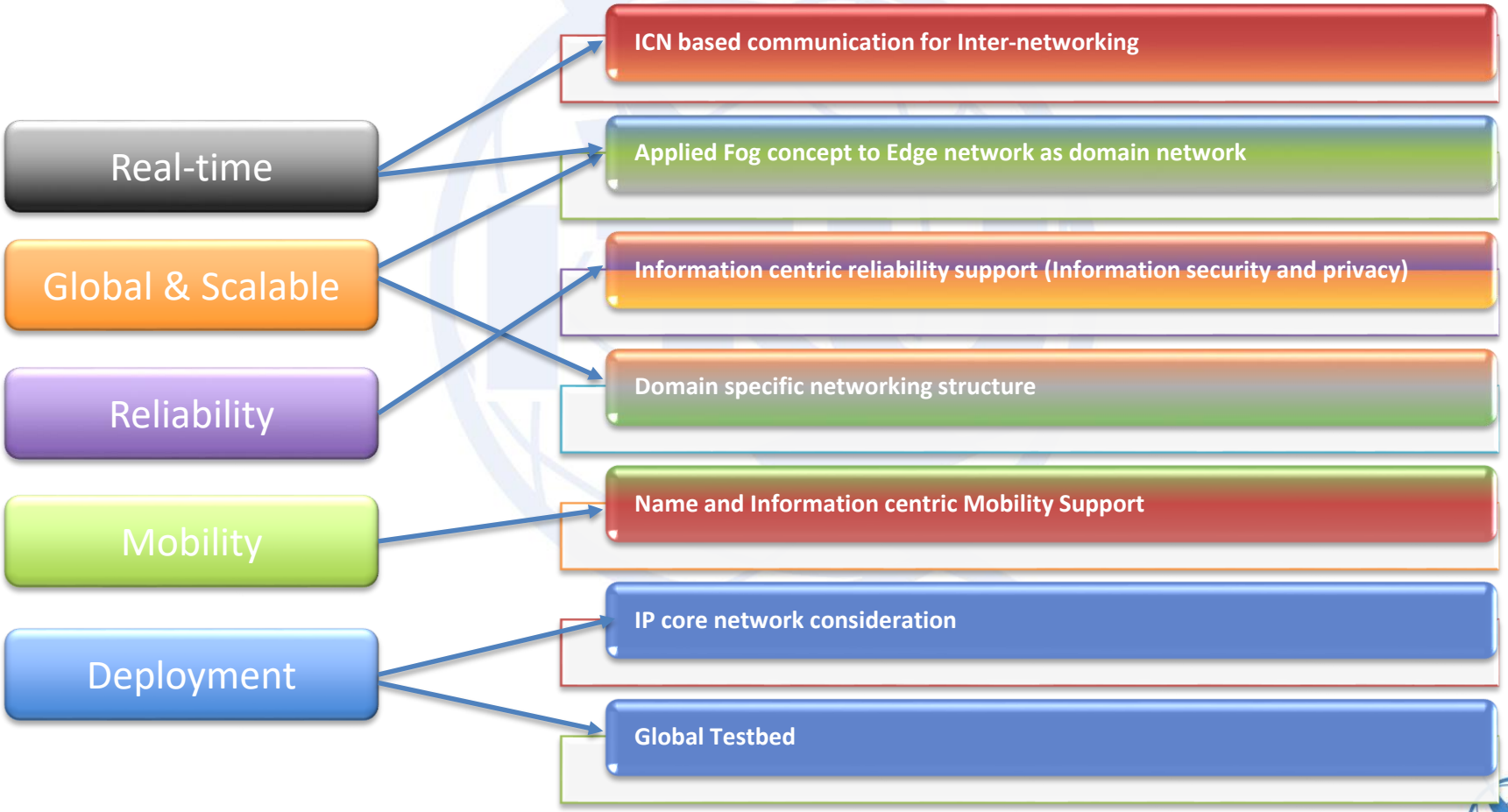
3. Requirements & Principles (1/2)

- ***General Requirements***



3. Requirements & Principles (2/2)

- ***Design Principles***



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3.1 Considerations for IoE

- ***When the IoT data generated is***
  - Delay-sensitive
  - High-volume
  - Trust-sensitive
  - (Intermittently) Disconnected

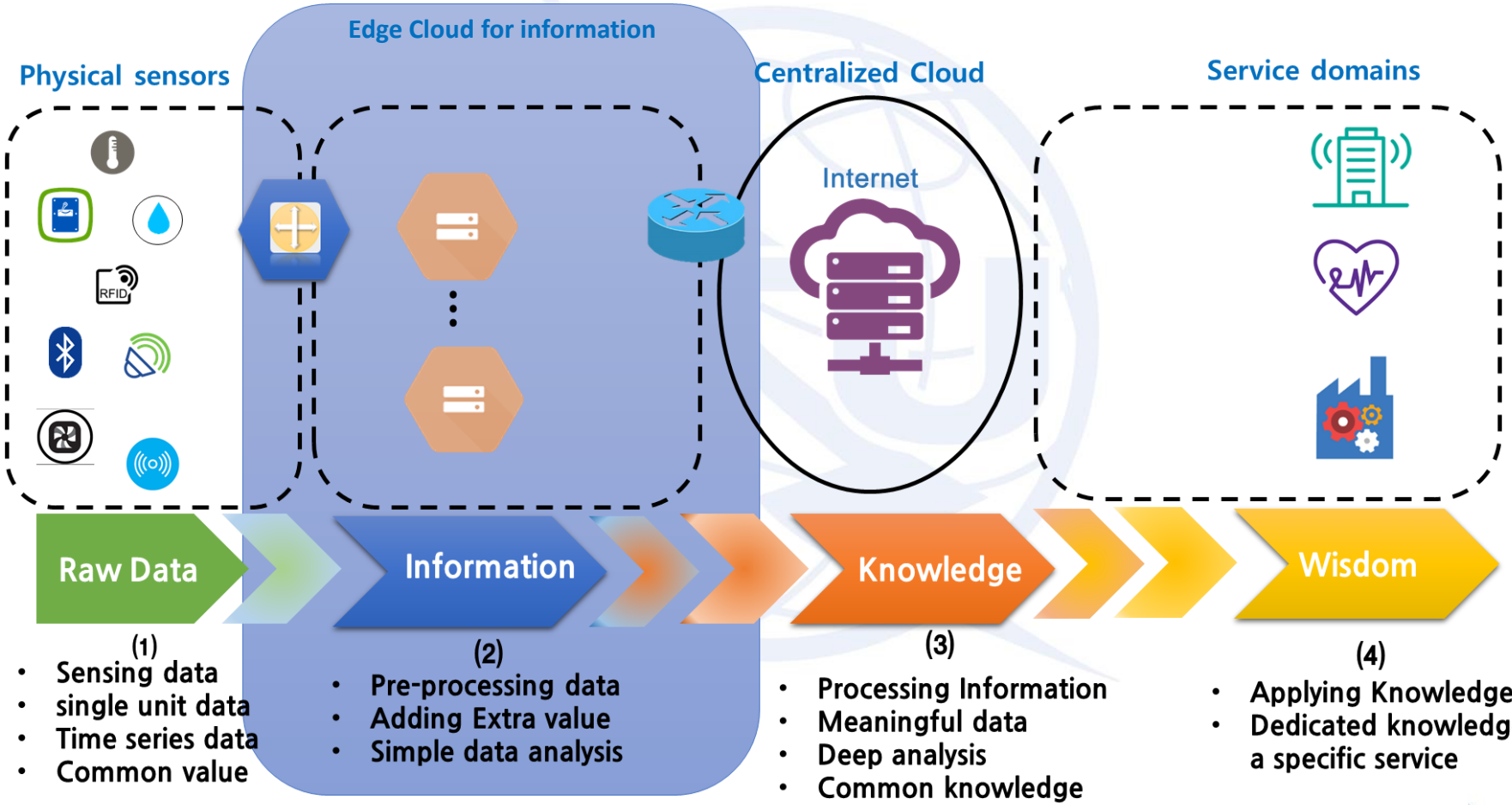
- Countless examples
  - Both near term & further out

Video Analytics

Augmented Reality

- Data heavy
- Compute intensive
- **Response times <30ms**
- Small form factor
- Low power

3.2 Considerations for Information



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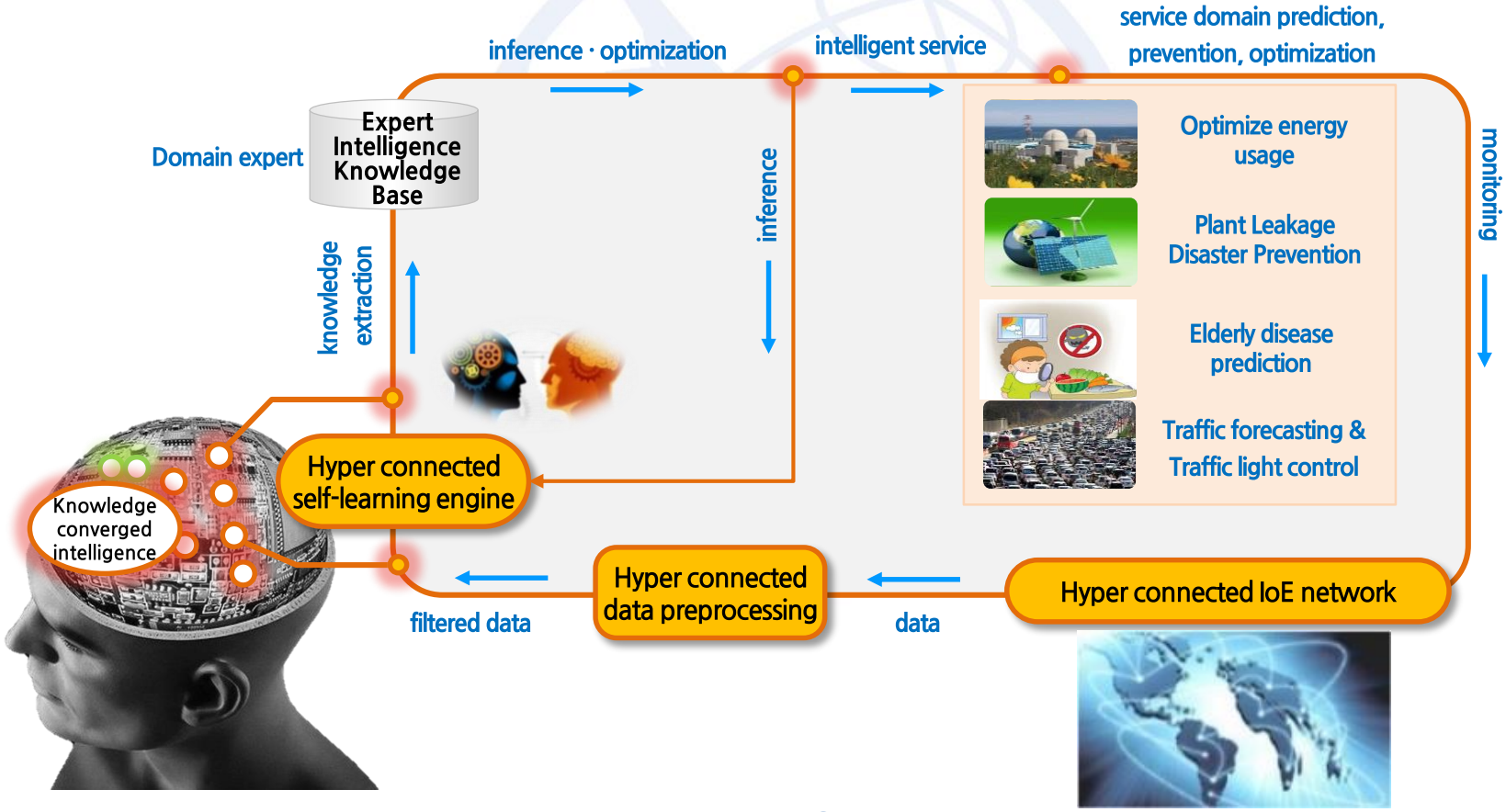
4. Proposed Intelligent Framework

self-learning Knowledge-converged Super Brain (KSB)

① Collect data with status ② Refine the collected data ③ Machine learning · knowledge extraction

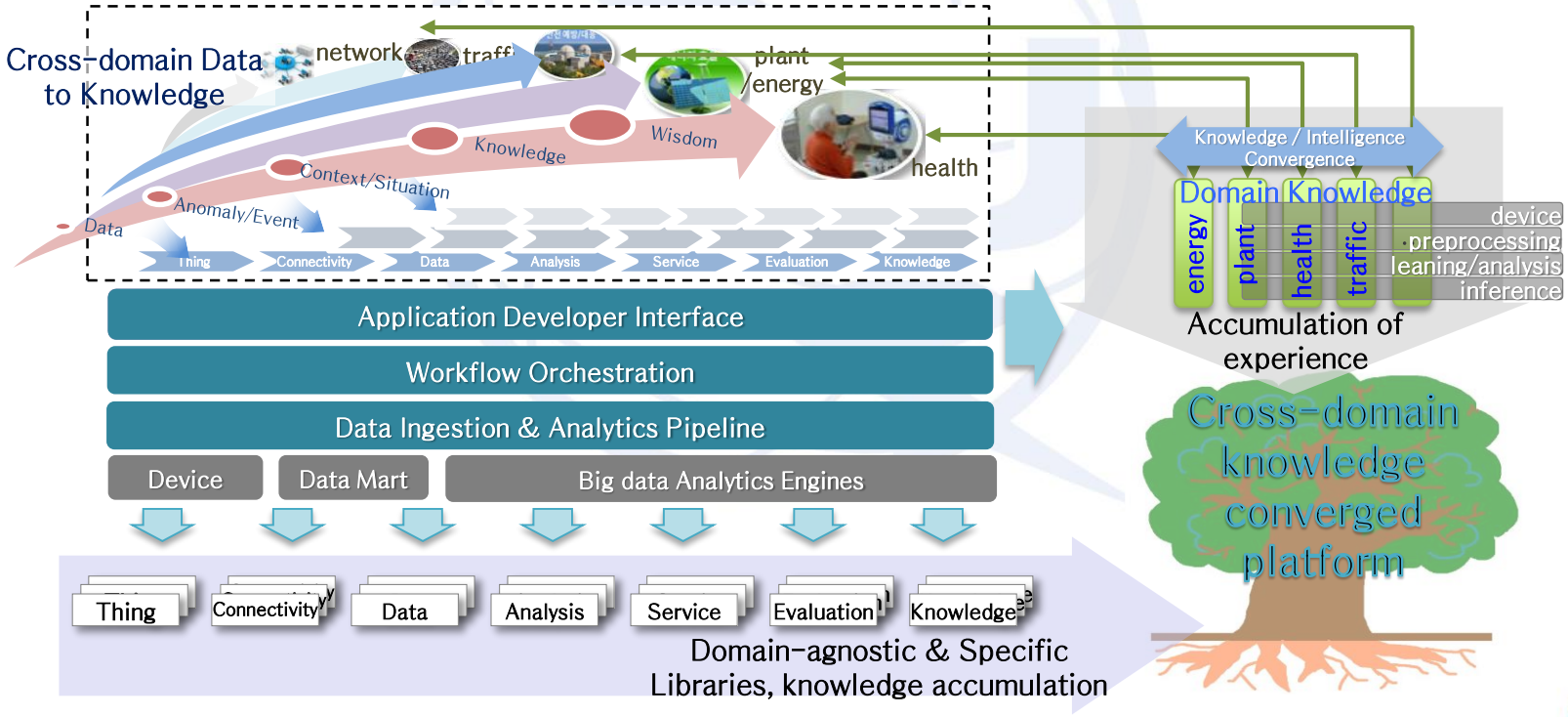
④ By inferring · optimizing by fusion with domain expert knowledge ⑤ Provision of prediction, prevention and optimization intelligence



※ KSB : Knowledge-converged Super Brain

4.1 Proposed self-learning platform

- All-around cross-domain knowledge convergence self-learning engine platform
  - to refine and self-learn the multimodal data collected from the IoE network, extract the knowledge,
  - to provide knowledge inference and optimized domain intelligence services by merging with domain knowledge



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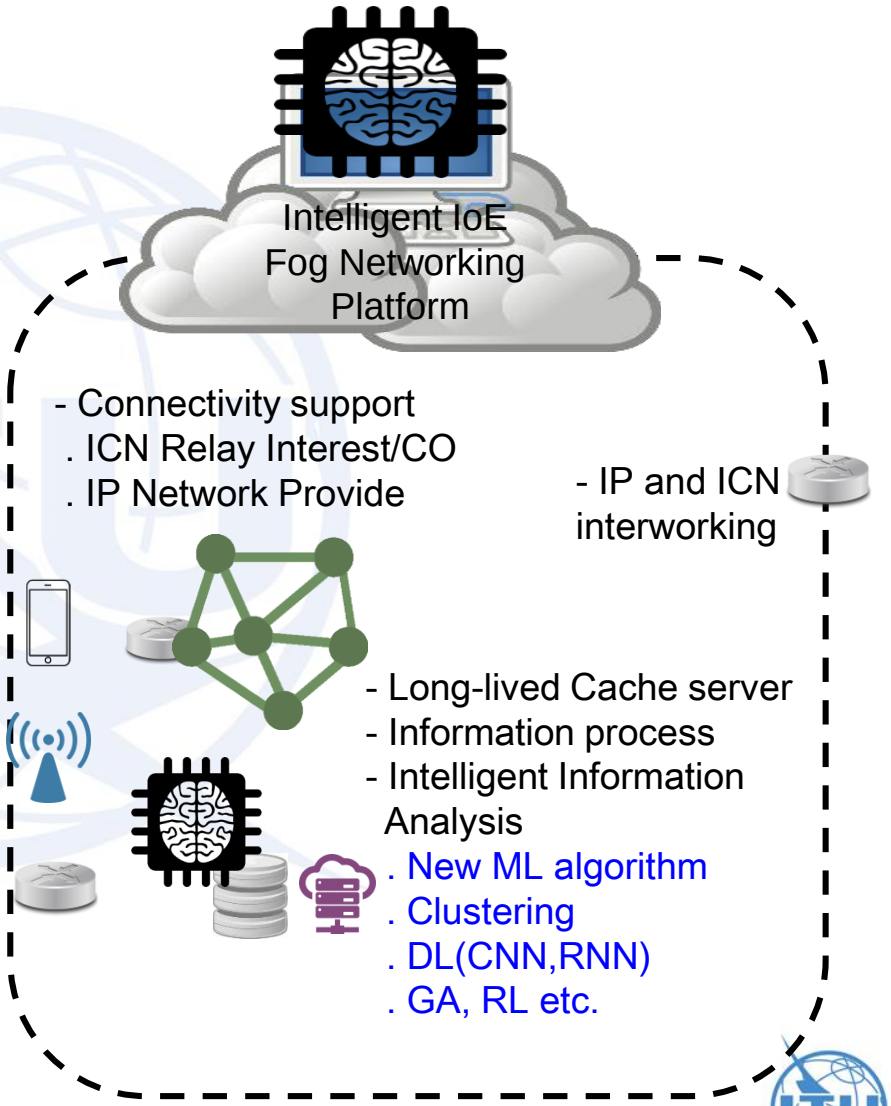
(Concept)

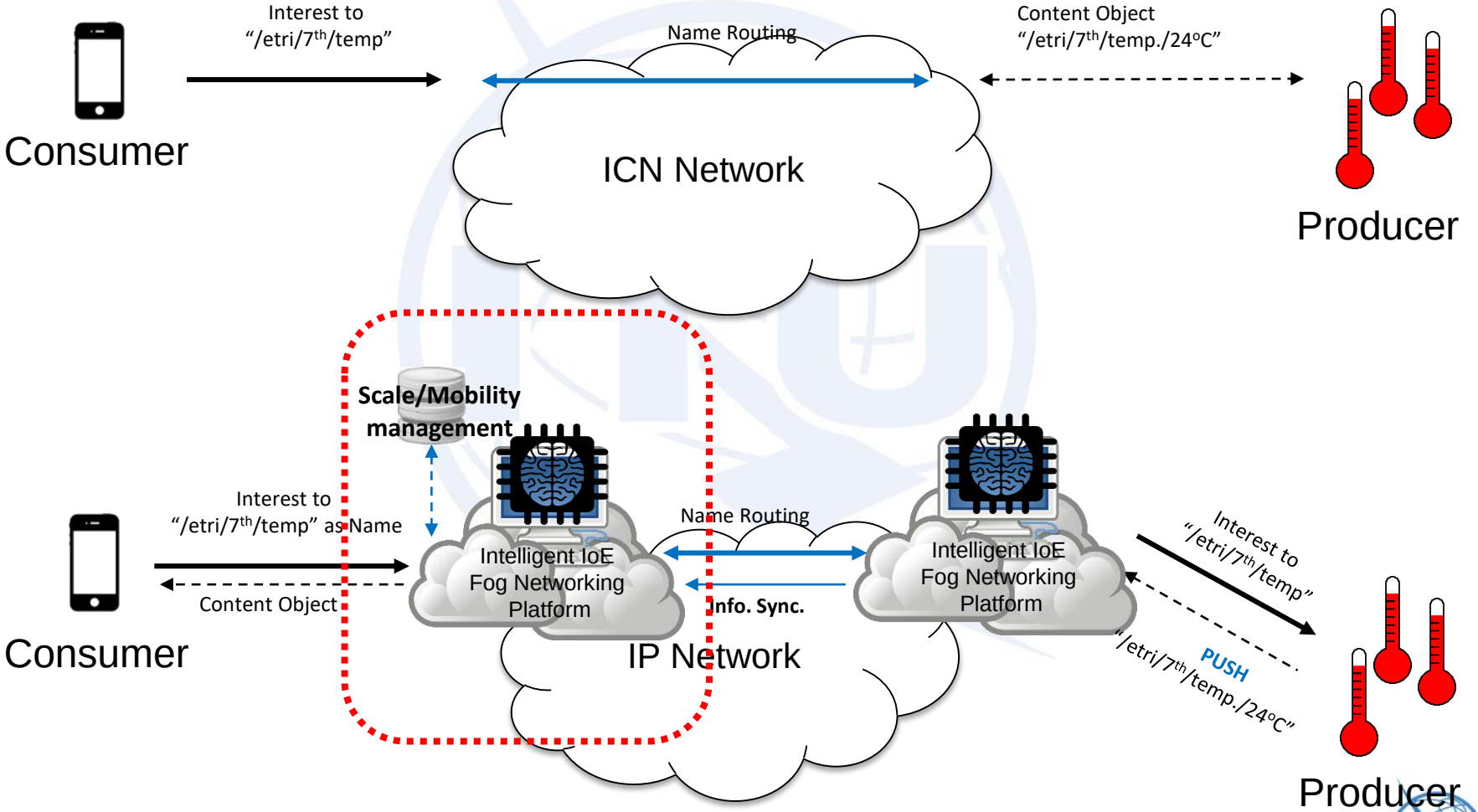
4.2 Proposed Fog/Edge Platform

- A novel Domain networking architecture
  - ICN based communication
    - *CICN based* Implementation
    - *IP and ICN interworking* with CICN
  - Fog/Edge computing concept
    - Define of specific purpose nodes
      - Gateway node, networking, storing, computing, Information process,
  - Intelligence
    - Intelligent Information analysis
      - *Applying ML*



* CICN(Community ICN) : ICN open source made by CISCO(formerly Parc CCNx)

4.2.1 Basic ICN vs. Proposed Fog

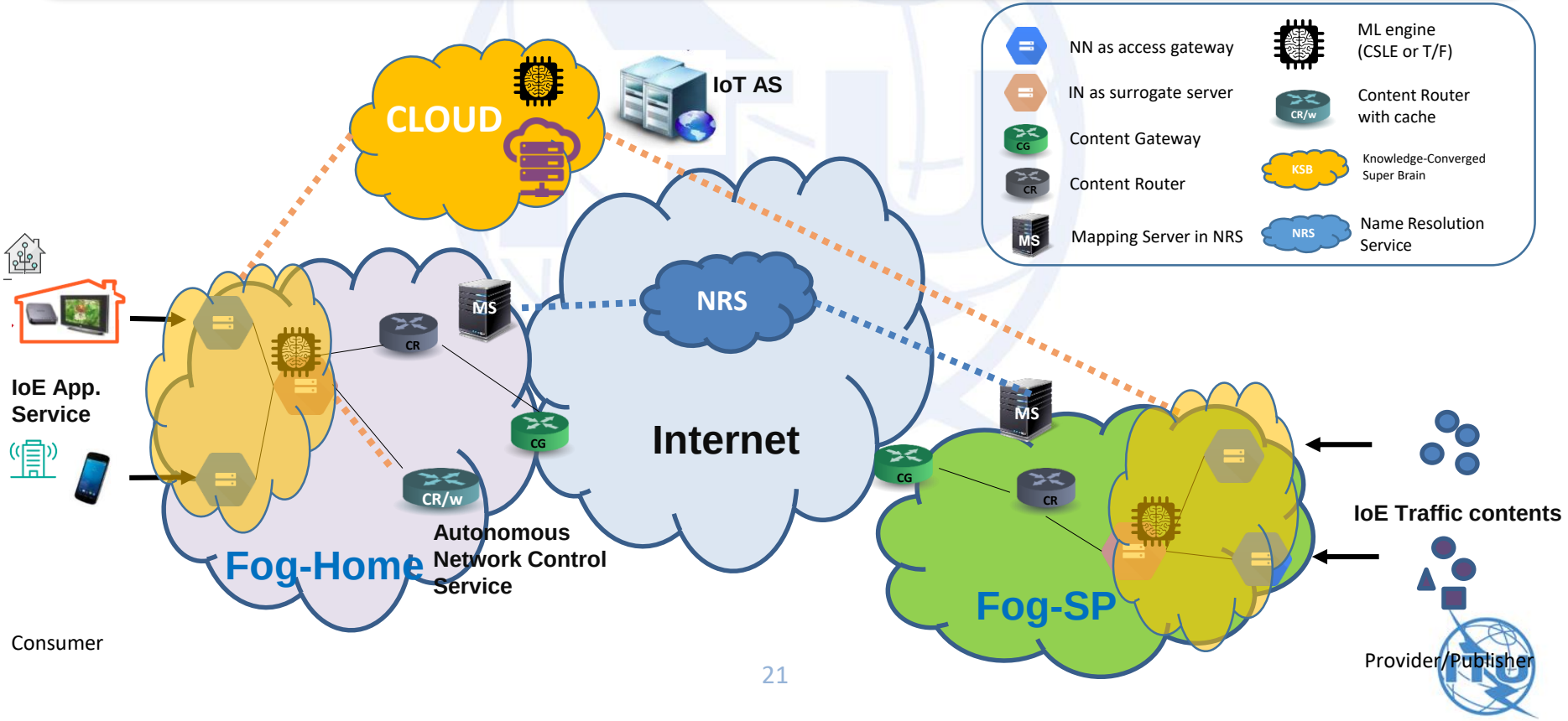


4.2.2 Information Process

- IoE data preprocessing
  - Classification of IoE information types (application types)
    - Classification of Content Object by CNN and RNN
  - Applying cache strategies
    - E.g., mission critical information must be push to Cloud or consumer directly without cache
- Interest analysis
  - Develop filter rules
    - Name based filter
  - Applying cache strategies
    - Prefetching Information
    - Decision of Cache rules

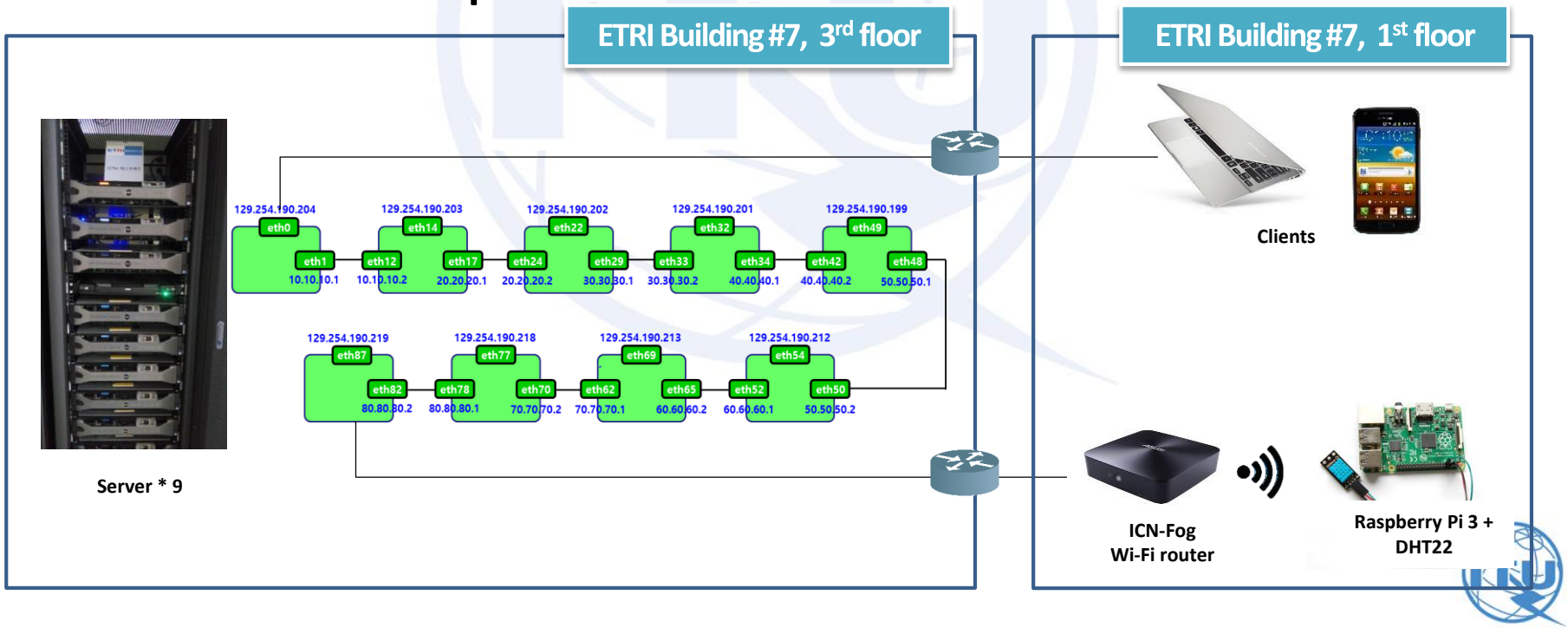
5. Prototype & Applying case

- 1. Information prefetching : Considering Autonomous network control aspects
- 2. Mobile Crowd Sensing : Considering Intelligent Application service aspects
- 3. Smart Construction : Considering Both Autonomous network control & Intelligent Application service aspects



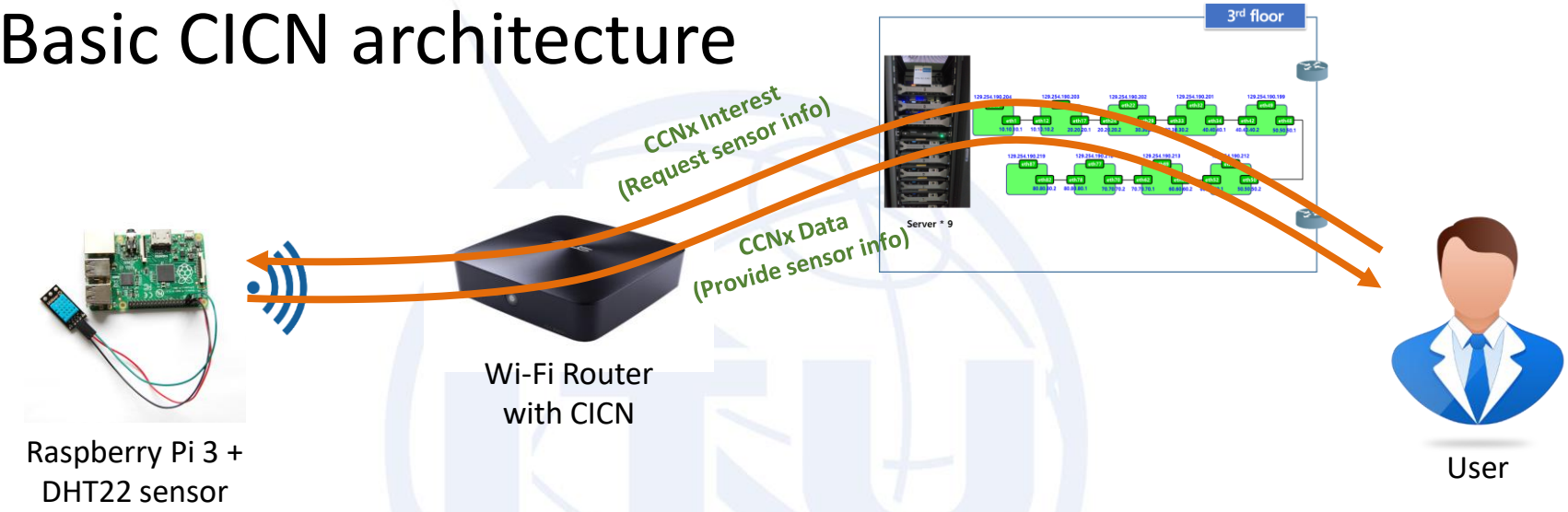
5.1 Applying case – Information prefetching (1/4)

- Purpose
  - Proposed Fog vs. basic CICN performance comparison
  - KPI : Information acquire time & packet loss ratio
- Testbed setup

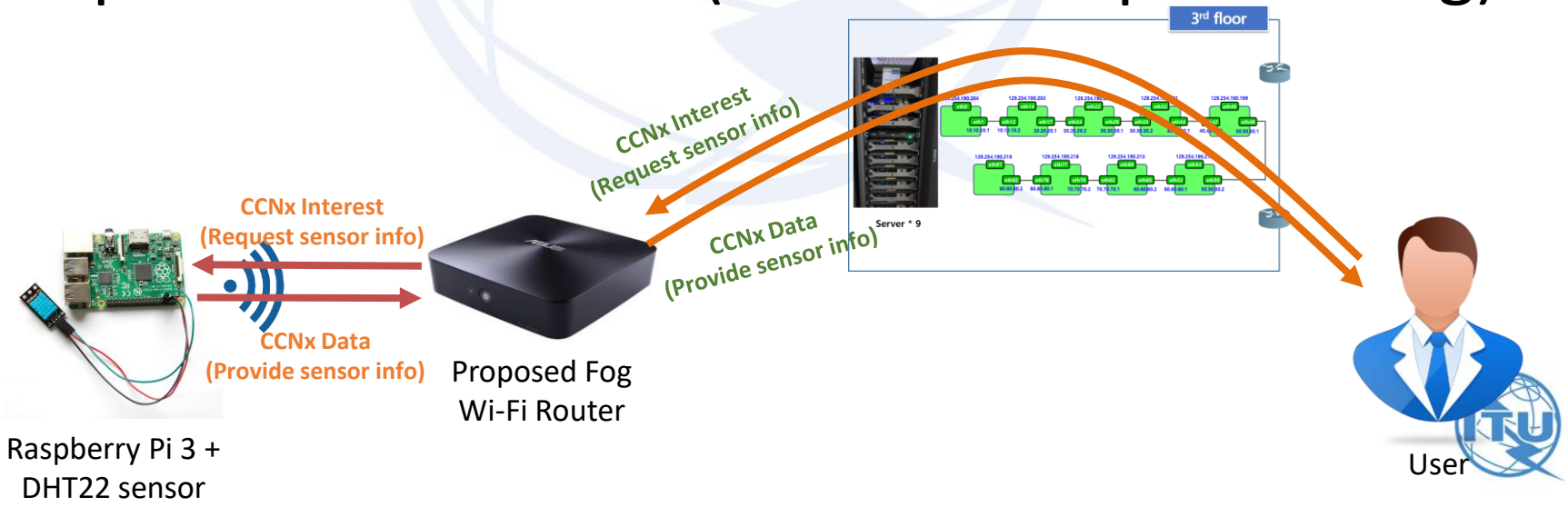


5.1 Applying case – Information prefetching (2/4)

- Basic CICN architecture

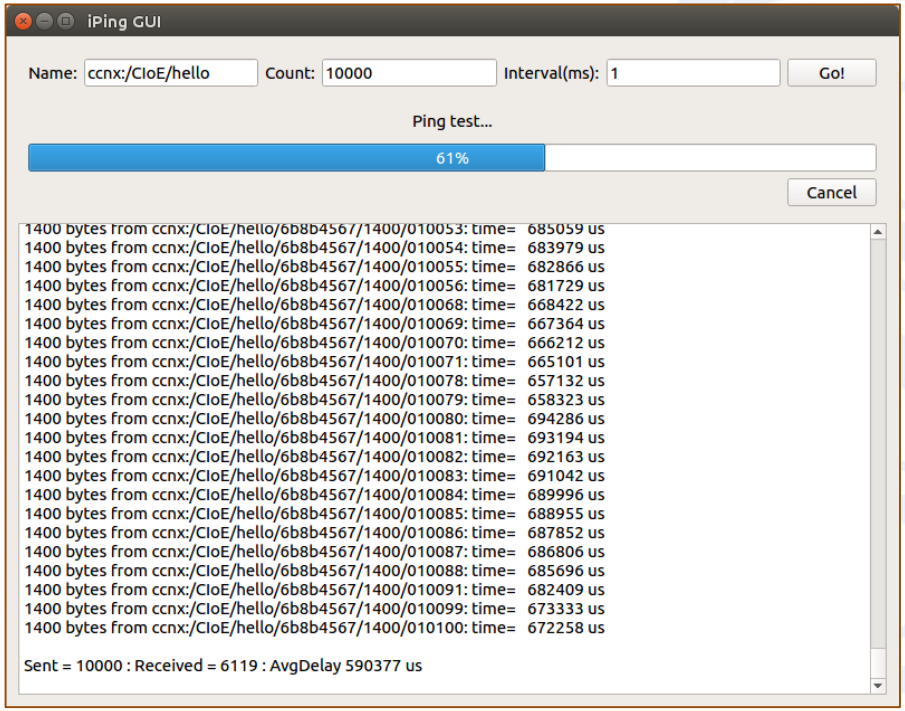


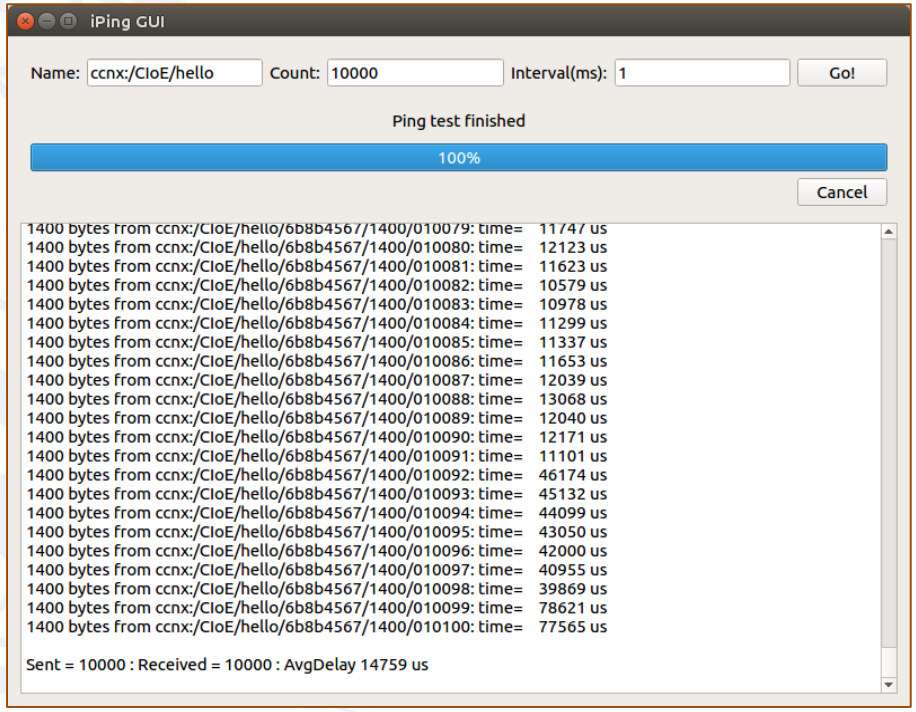
- Proposed architecture (Information prefetching)



5.1 Applying case – Information prefetching (3/4)

- Result





CICN(Prefetching off)

Proposed Fog(Prefetching on)

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5.1 Applying case – Information prefetching (4/4)

- Summary
  - Light traffic: transfer 100 interest per every 1 sec
  - Heavy traffic: transfer 10^7 interest per every 100 usec

	CICN		Proposed Fog	
	Light	Heavy	Light	Heavy
Info. Query time	56 msec	786 msec	**28 msec**	**30 msec**
Packet loss ratio	0%	42%	**0%**	**0%**

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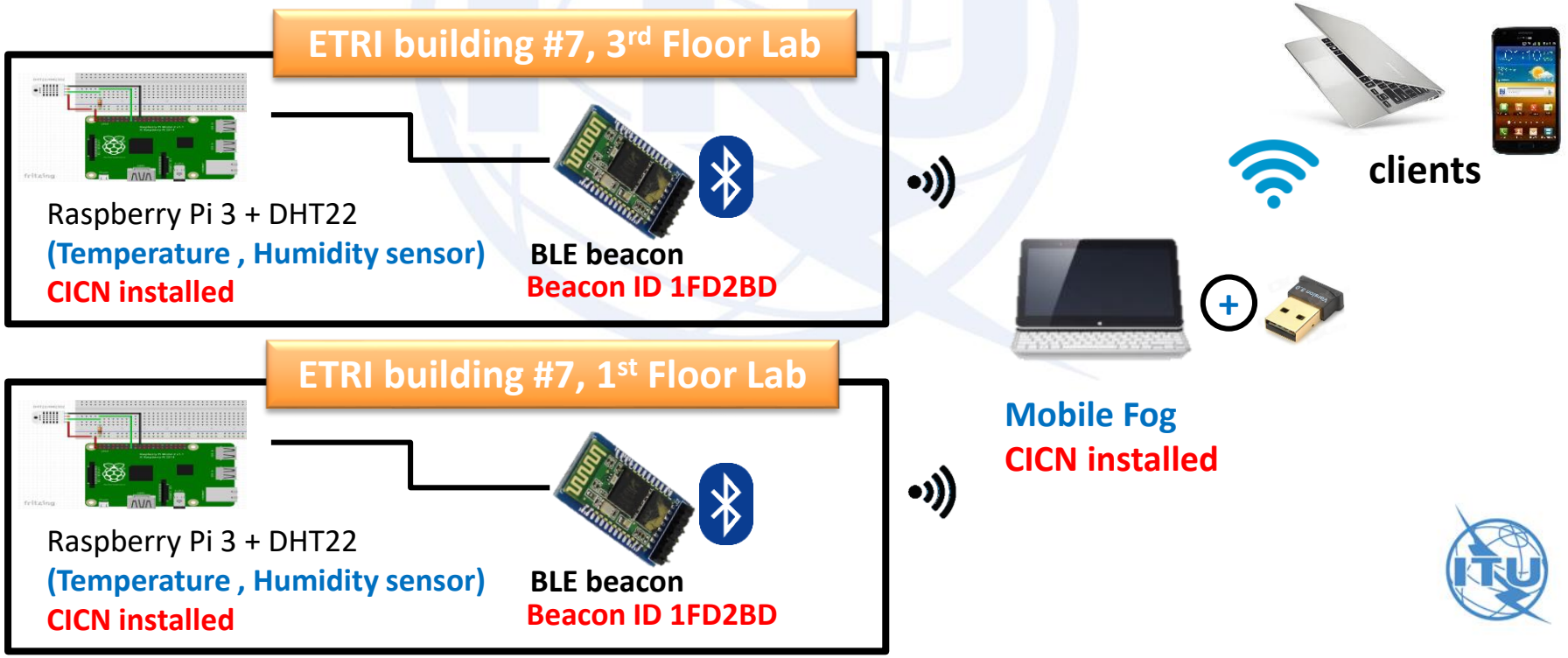
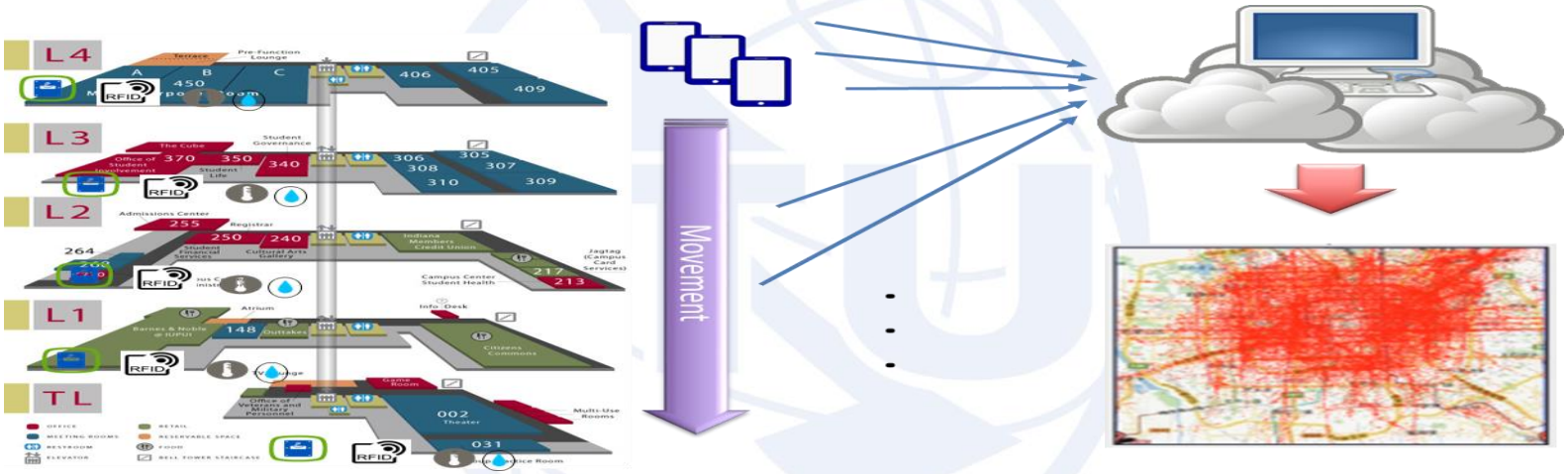
5.2 Applying case – Mobile crowd sensing (1/4)

- Purpose
  - Implementation of ICN based Mobile Crowd Sensing
  - characteristic : Mobile Fog & without IP
- Testbed setup



5.2 Applying case – Mobile crowd sensing (2/4)

- Basic MCS architecture
  - **Crowdsourcing** of sensor data from Mobile devices



- Proposed Mobile Fog based MCS architecture
  - **Acquire data from Mobile Fog device**
  - **Only transfer Data analysis result to Central Cloud**
    - **small amount of volume**

5.2 Applying case – Mobile crowd sensing (3/4)

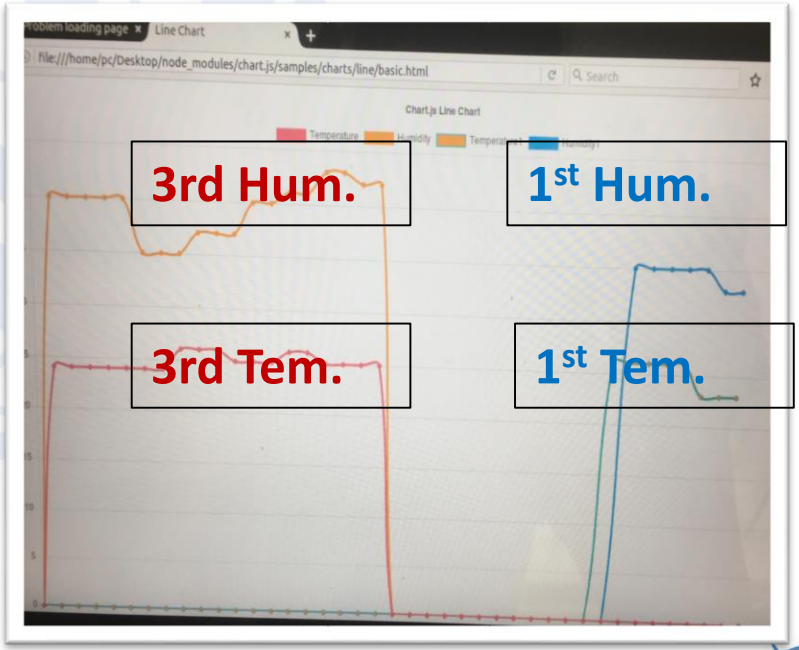
- Result


Mobile Fog

3rd Floor Lab Visit Movement 1st Floor Lab Visit

screen of client (3rd Floor)

clients



screen of client (1st Floor)

5.2 Applying case – Mobile crowd sensing (4/4)

- Summary
  - New MCS based on proposed fog architecture
  - Service implementation **based on Ethernet connectivity using ICN** (without IP)
  - **Data collection based on local area** using BLE beacon

	Mobile Crowd Sensing	Propose Fog based MCS
Connectivity	• **IPv4/IPv6, TCP/UDP, HTTP/CoAP**	• **Ethernet, ICN App.**
Data collection	• **Cloud based data collection**	• **Fog node based data collection**

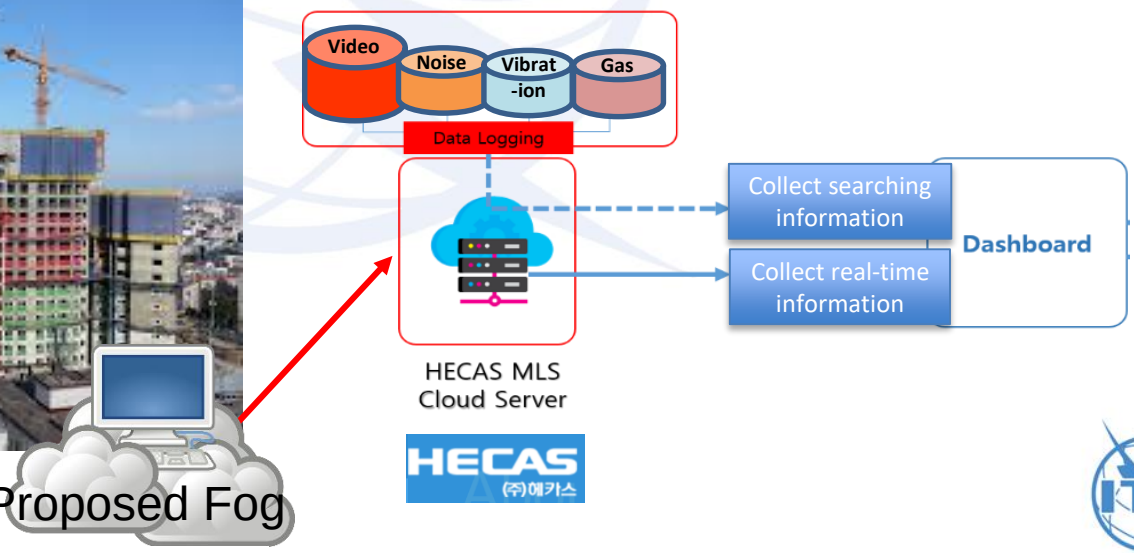
5.3 Applying case – Smart construction

- Purpose
  - Implementation of monitoring service of construction
  - Characteristic : scalable media data transfer based on alarm

    * We plan to co-work with HECAS (Korean vendor)
- Testbed setup

Bundang-gu, Sungnam-si, Kyunggi-do, Korea

construction



6. Summary

- ***Data are transformed into wisdom through the IoE computing architecture including Intelligent Fog networking platform.***
  - We assume that huge amount of sensed data are generated from smart things, and these data may be formed as single unit data, time series data, or meaningless digits.
  - Firstly these data are *processed or analyzed at the Fog platform*, so that the result of analysis may be transmitted to Cloud.
  - After then accumulated *these pre-analyzed data as called information* are again processed to make *common knowledge*.
  - Finally, the common knowledge will be applied to *specific IoE service domains as the wisdom*.

Thank you.

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