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Integrated network control architecture for terrestrial and non-terrestrial network convergence in beyond 5G systems

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Ved P. Kafle

National Institute of Information and Communications Technology, Japan

(Coauthors: Mariko Sekiguchi, Hitoshi Asaeda, and Hiroaki Harai)

Session 1 – Some perspectives on future networks

Paper S1.1

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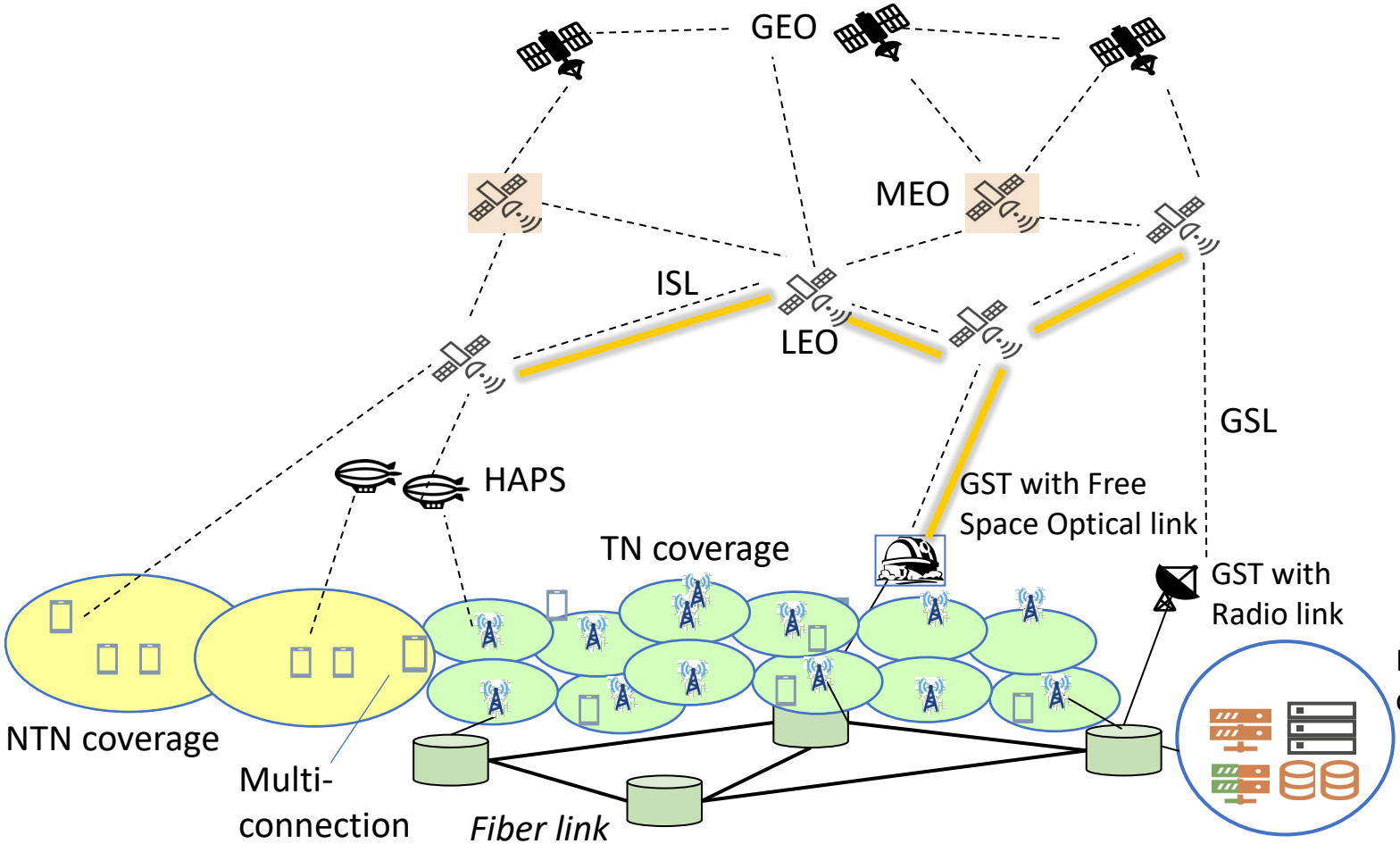
Outline

- Introduction to TN and NTN convergence
- Related works
- Individual network segment control architecture
- Integrated network control architecture
- Features of integrated network control architecture
- Conclusion and future work

TN: Terrestrial network
NTN: Non-terrestrial network

Introduction to TN and NTN convergence (1/2)

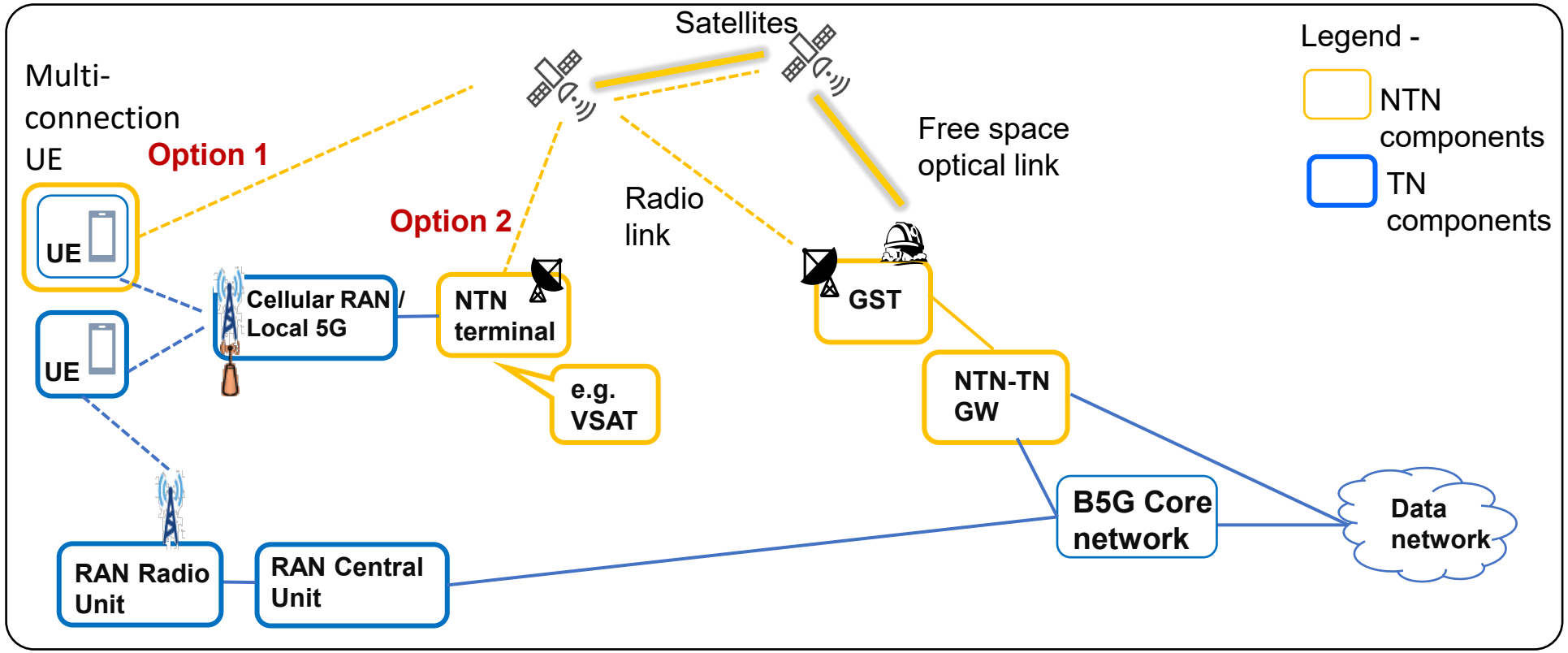
- TN and NTN convergence – a high-level image



GEO: Geostationary earth orbit
MEO: Medium earth orbit
LEO: Low earth orbit
ISL: Inter-satellite link
GST: Ground station
GSL: Ground-to-satellite link
HAPS: High altitude platform system

Introduction to TN and NTN convergence (2/2)

- Fixed, mobile, satellite convergence – involved network segments image



GST: Ground station, GW: Gateway, RAN: Radio access network, UE: User equipment

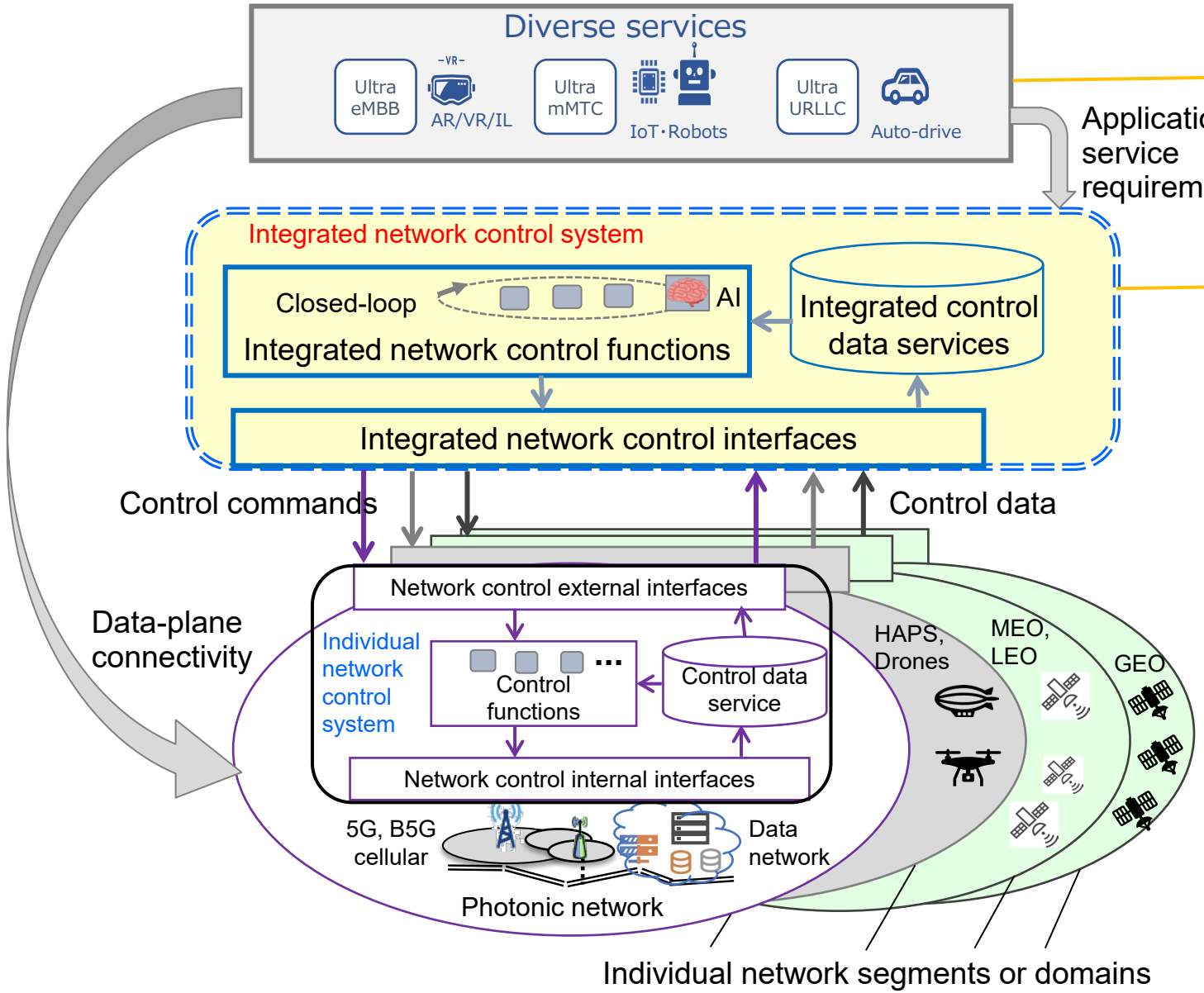
- Integrated network control system architecture still missing (Focus of this research)

Related works

- European Commission (EC) funded projects
  - Sat5G: Satellite and terrestrial networks for 5G
  - 5G- ALLSTAR: 5G agile and flexible integration of satellite and cellular
  - VITAL: Virtualized hybrid satellite-terrestrial systems for resilient and flexible future networks
- European Space Agency funded project
  - SATis5: Demonstrator for satellite-terrestrial integration in the 5G context
- Research activities in Japan
  - NICT's Beyond 5G6G White paper; Space ICT Promotion Initiative Forum
- 3GPP and ETSI reports
  - 3GPP TR 2.822, TR 28.80, TR 23.737; ETSI TR 103 611
- ITU standardization activities
  - ITU-T SG13 (non-radio aspects of FMSC architecture), ITU-R W5D

FMSC: Fixed, mobile and satellite convergence

Scenario of TN and NTN convergence through integrated network control system



- Enabling ultra eMBB, ultra mMTC, and ultra URLLC services from anywhere at any time

- TN and NTN collectively monitored and controlled from the integrated network control system in control plane
  - Controlling resources
  - Monitoring performance
- Major functional components
  - Integrated network ctrl func.
  - Integrated ctrl data service
  - Integrated network ctrl interfaces

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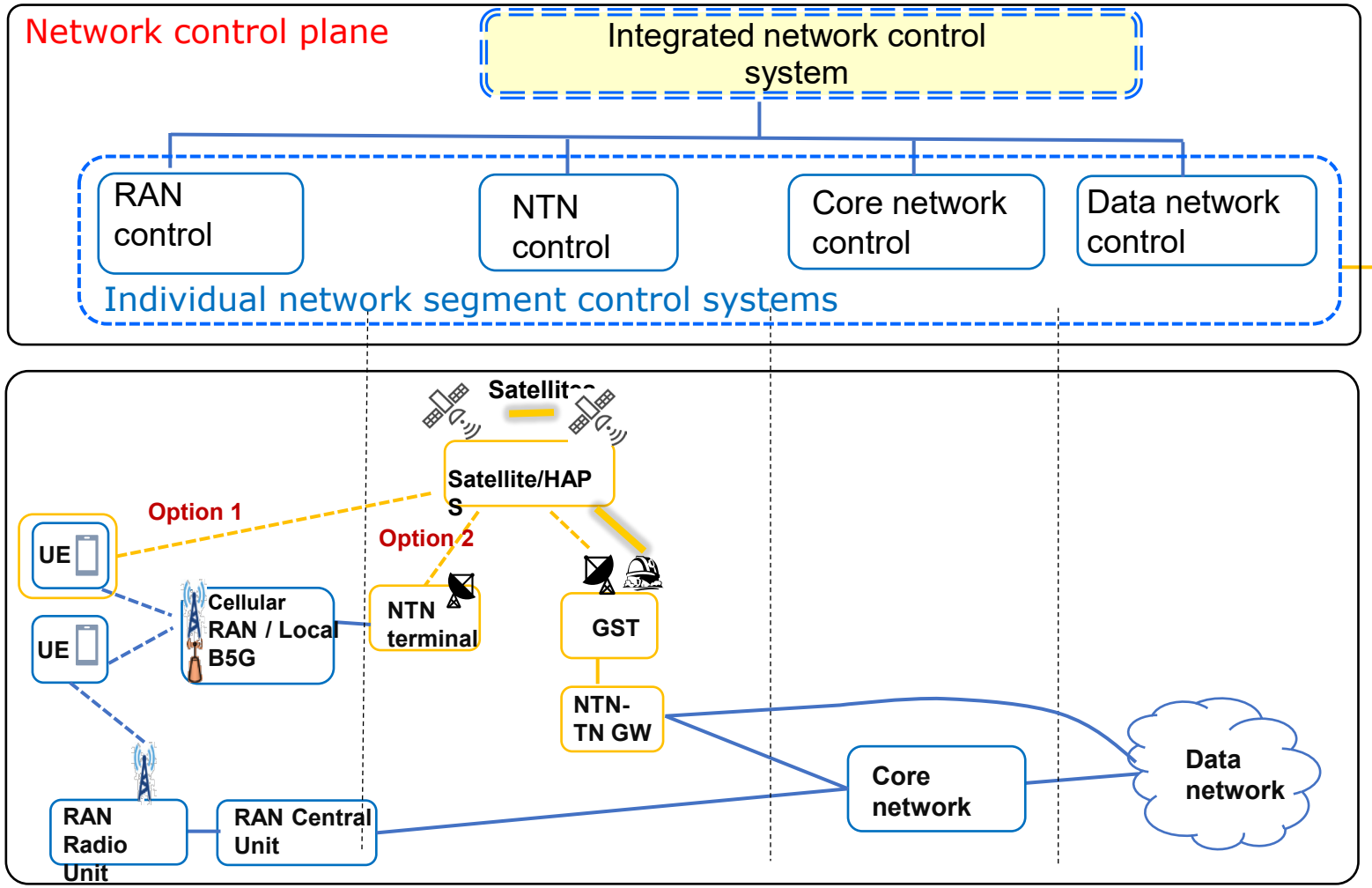
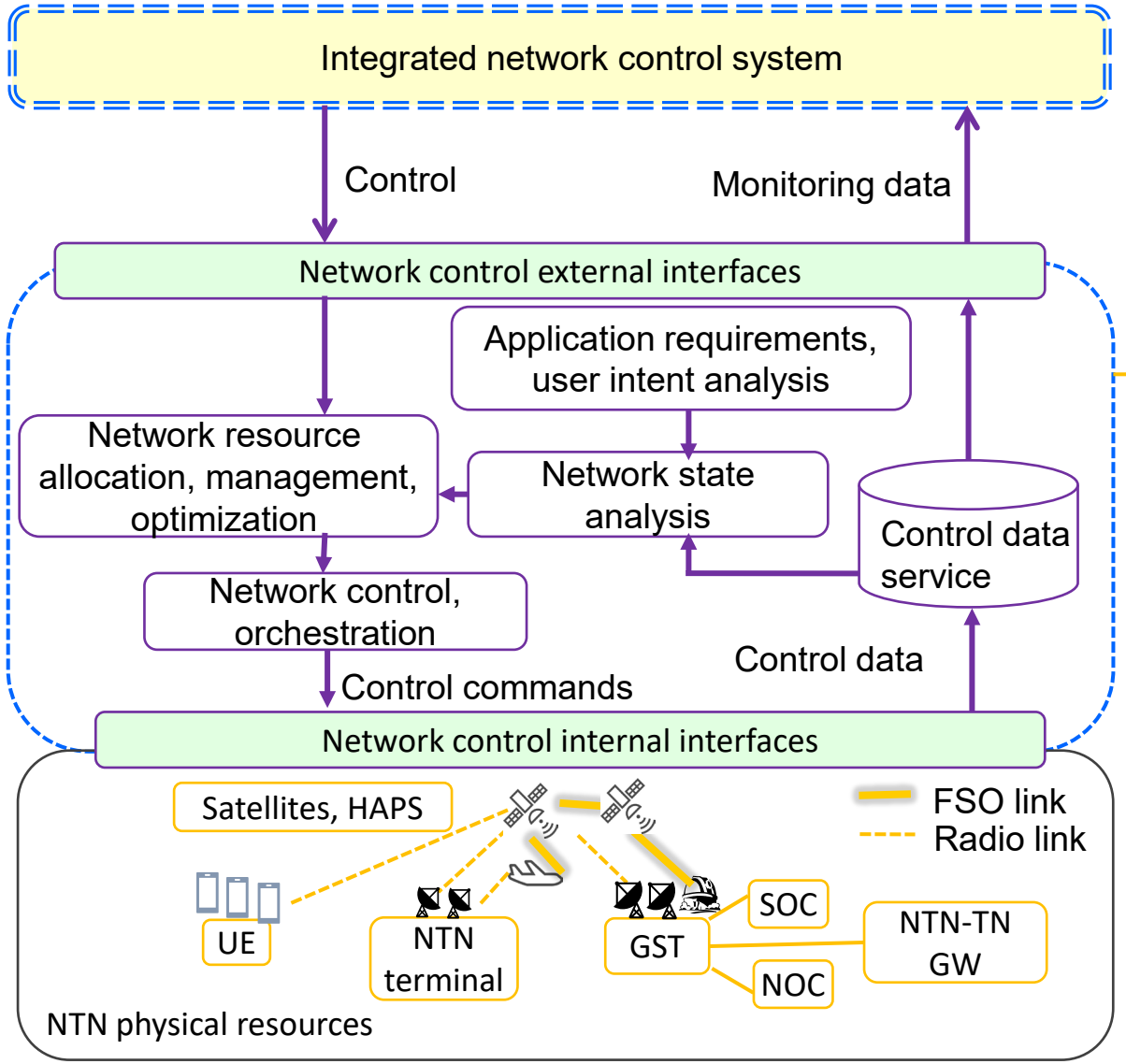
Individual network segments and their control systems in TN and NTN convergence



Individual network segments

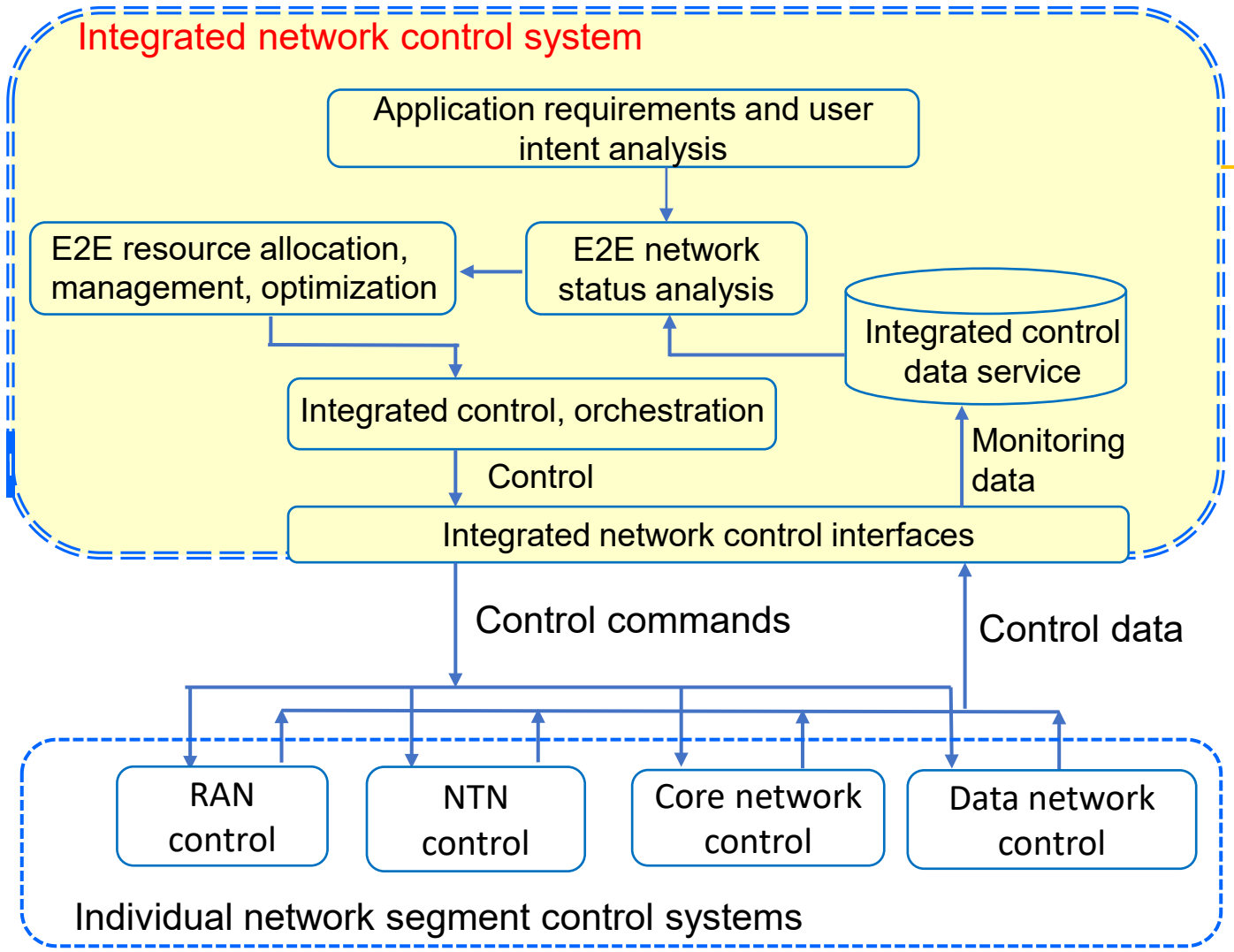
- In control plane, each network segment is managed by its own control system.

Functional architecture of individual network segment control system



- Individual network control system consists of functions:
  - App requirements, user intent analysis
  - Network resource allocation, management, optimization
  - Network state analysis
  - Control data service
  - Network control, orchestration
- Two sets of interfaces:
  - Network control internal interfaces
    - Control and monitoring of individual network segment
  - Network control external interfaces
    - Providing control data to and obtaining control commands from integrated network control system

Functional architecture of integrated network control system



E2E: End-to-end

- Integrated network control system consists of functions (similar to individual network segment control system but of E2E scope):
  - App requirements, user intent analysis
  - E2E resource allocation, management, optimization
  - E2E network state analysis
  - Integrated control data service
  - Integrated control, orchestration
- Integrated network control interface
  - Receiving control data from and sending control commands to individual network segment control system

Features of integrated network control architecture

- End-to-end network control and monitoring
  - Integrating network segments in control plane and enabling convergence in data plane for offering high-quality communication services
- End-to-end network resource sharing
  - Resource sharing of both TN and NTN network segments through standard interfaces and functions
- Unified representation of resources
  - TN virtualized network and computing resources and NTN RF link/GST resources
- Technology-agnostic control operations
  - Technology-agnostic control mechanisms and open interfaces
- Promoting network control automation
  - Data-oriented, closed-loop control mechanisms, leading to the automation of individual and integrated network control functions

Summary and future work

- Presented a preliminary design of integrated network control architecture for TN and NTN convergence
  - Enabling end-to-end network control and monitoring for offering reliable services in any place at anytime
- Development of experimental system for verification in an emulation environment is ongoing
- Parallelly, standardization in ITU-T has started
  - Initiated a Recommendation draft on fixed, mobile, satellite convergence – Integrated network control architecture in ITU-T SG13 (November 2022)

Thank you!

Contact: Ved P. Kafle, PhD
Email: kafle(at)nict.go.jp