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Service decoupling for open and intelligent service-based RAN

Key words: Service decoupling; Open and intelligent; Service-based radio access network (RAN); Graph theory; Full-service 6G network

Corresponding author: Chunjing YUAN
E-mail: yuanchunjing@ict.ac.cn
ORCID: https://orcid.org/0000-0001-5490-971X

Motivation

1. Native AI needs an open and decoupled service-based RAN. Therefore, RANs need to undergo a disruptive evolution based on service-based architecture (SBA) characterized by software and decoupling.
2. The protocol stack is decoupled based on the engineer's prior development experience with protocols and software, rather than using a theoretical approach. There is no widely accepted solution for RAN decoupling.
3. The functions of the control plane (CP) have more complex connection characteristics. The signaling procedure involves multiple network functions, each capable of appearing in multiple signaling procedures.

Main idea

1. We initially analyze the characteristics of the protocol stack and the interoperability among its functions. A decoupling approach, grounded in a theoretical framework for data analysis rather than relying on expert experience, is then proposed.
2. The functional connection and interaction of the CP are represented by constructing an undirected weighted graph, followed by achieving decoupling of the CP through a minimum spanning tree.
3. The service-based RAN and CN are both SBAs, which can be connected and interacted with through SBI. Given the overlapping and redundant functionalities between them, this study explores an integration and decoupling scheme for the RAN and CN.

Method

1. The RAN issues new signaling information after multi-processing when the CP receives a message from the CN or terminal. In the CP, multiple components are responsible for completing the signaling procedure. Specifically, the component is accountable for processing the signaling.

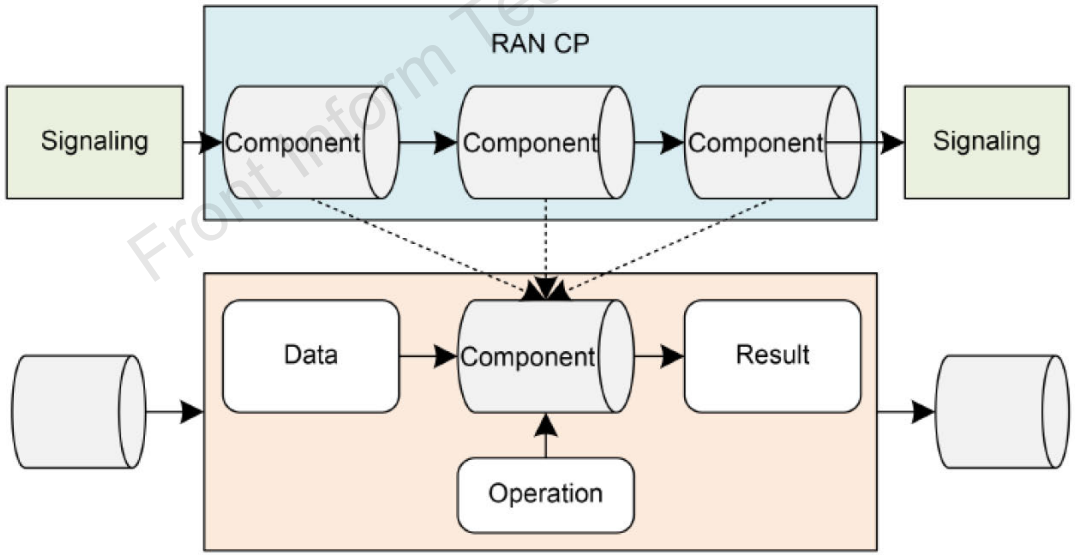

Fig. 2 CP handling a signaling procedure (CP: control plane; RAN: radio access network)

Method

2. The strong coupling between components can be considered as forming a service, which makes the capabilities of the service more focused and independent.

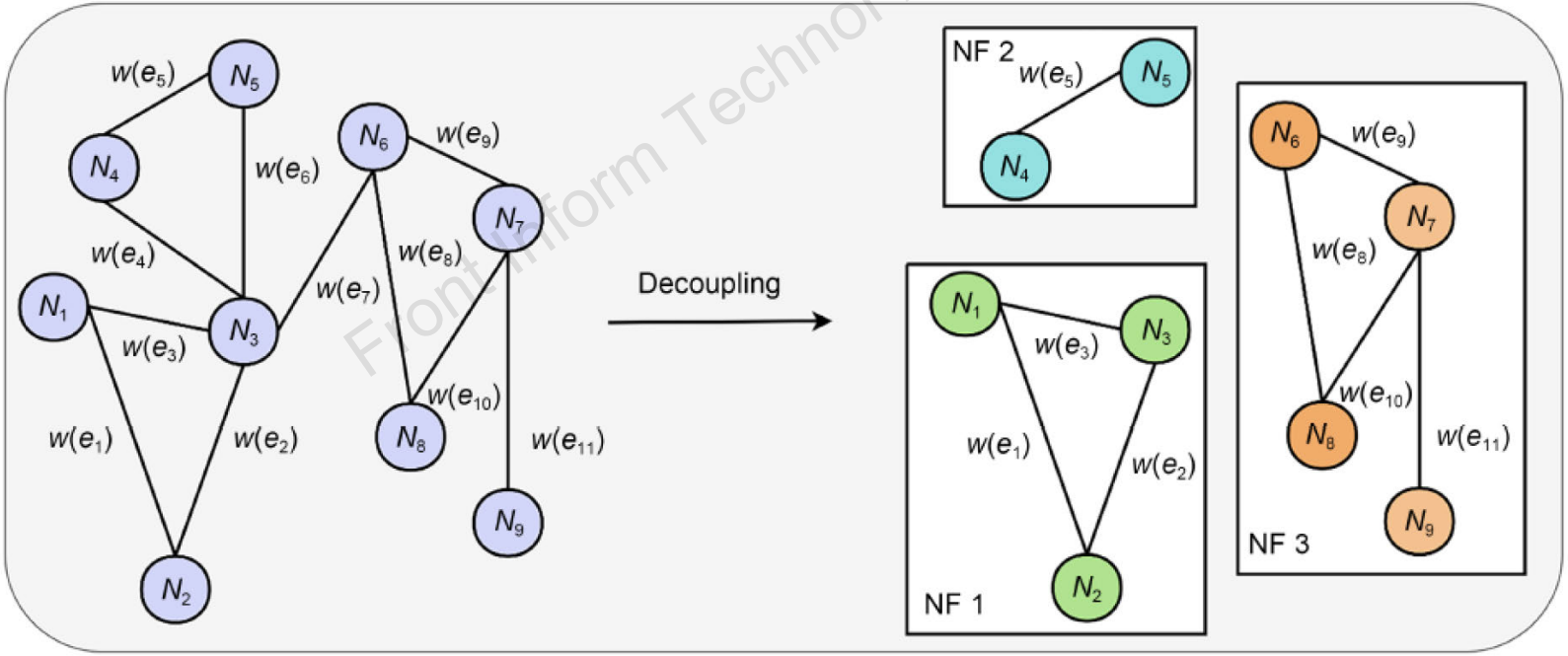

Fig. 4 Decoupling model (NF: network function)

Method

3. For the integration of RAN and CN CP, the connection between the contexts of RAN and CN must first be established. The interaction between components is graphed using signaling procedures, and the functions of the CN and RAN are aggregated together through graph clustering.

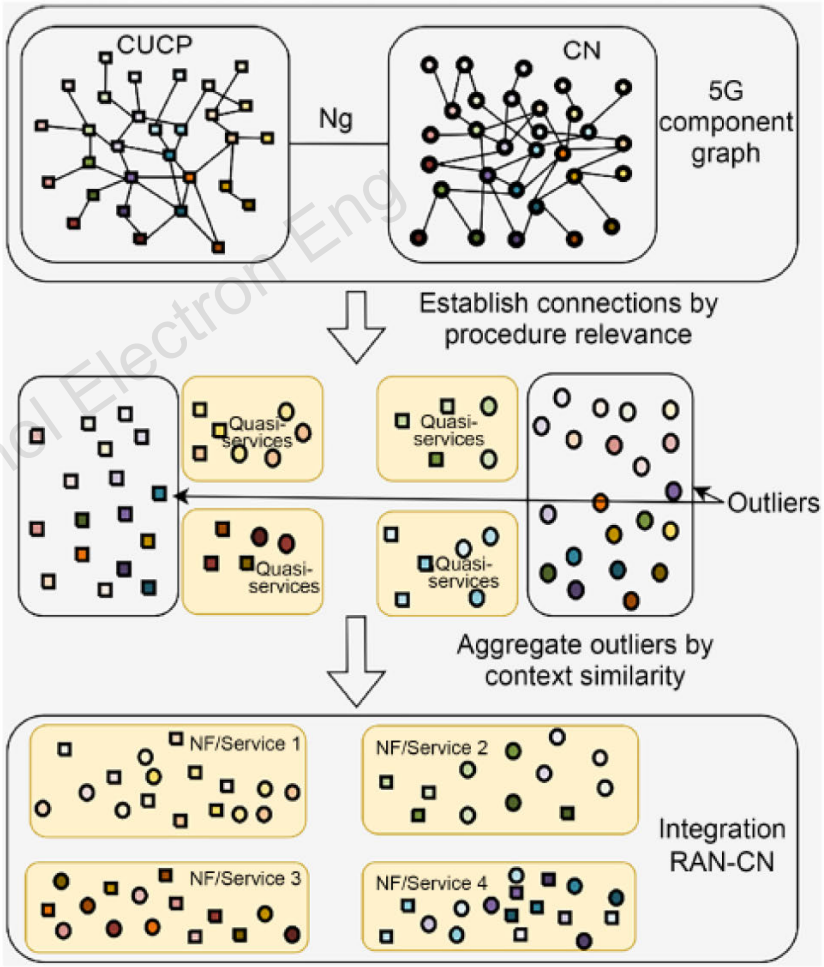

Fig. 7 Integration decoupling steps (CUCP: centralized unit control plane; CN: core network; NF: network function; RAN: radio access network). References to color refer to the online version of this figure

Major results

Decoupling performance

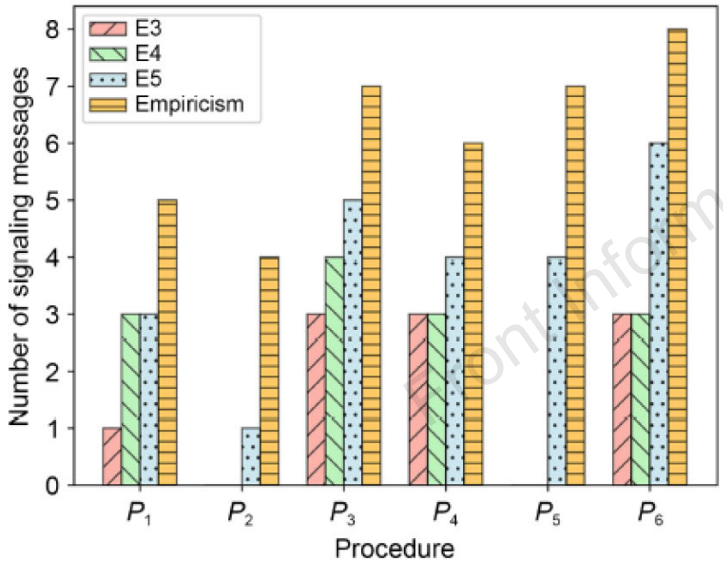

Fig. 8 Number of serviced-based radio access network (RAN) signaling messages

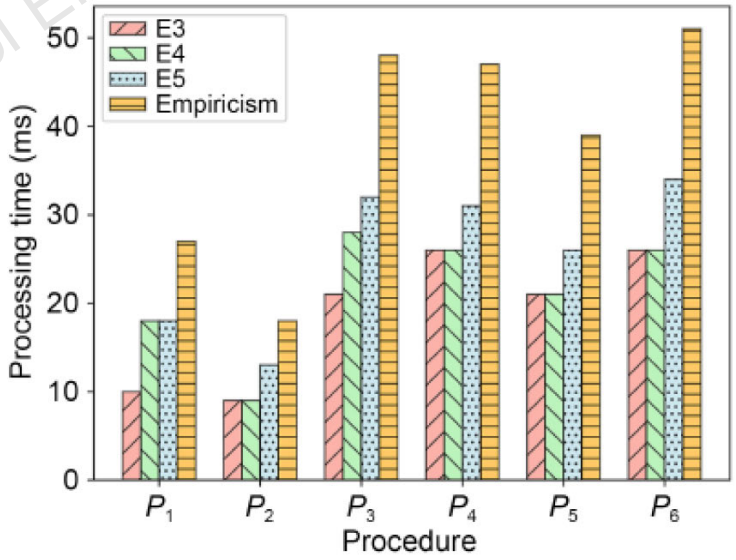

Fig. 9 Service-based radio access network (RAN) control plane (CP) processing time

Major results

Decoupling performance

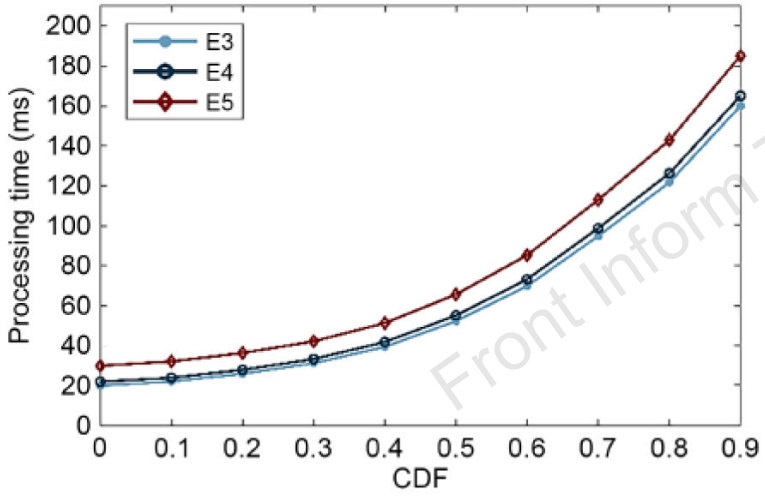

Fig. 11 Call frequency and processing time in congestion (CDF: cumulative distribution function)

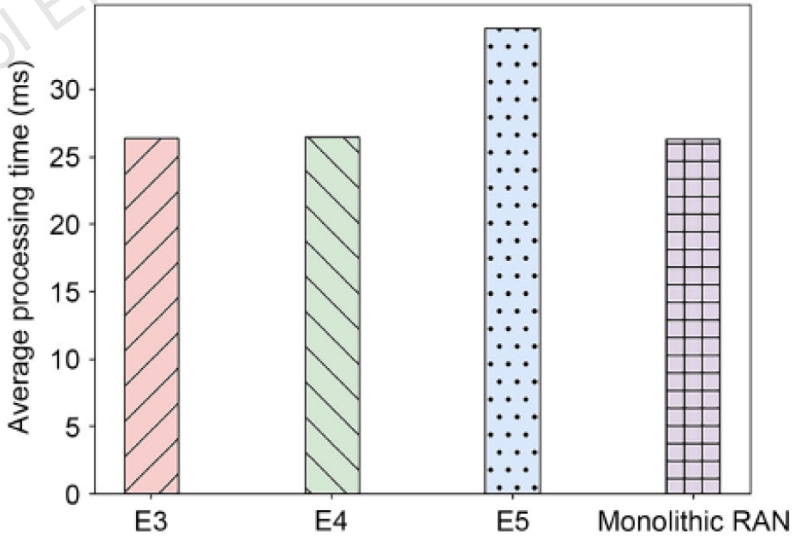

Fig. 12 Average processing delay (RAN: radio access network)

Major results

Integration decoupling performance

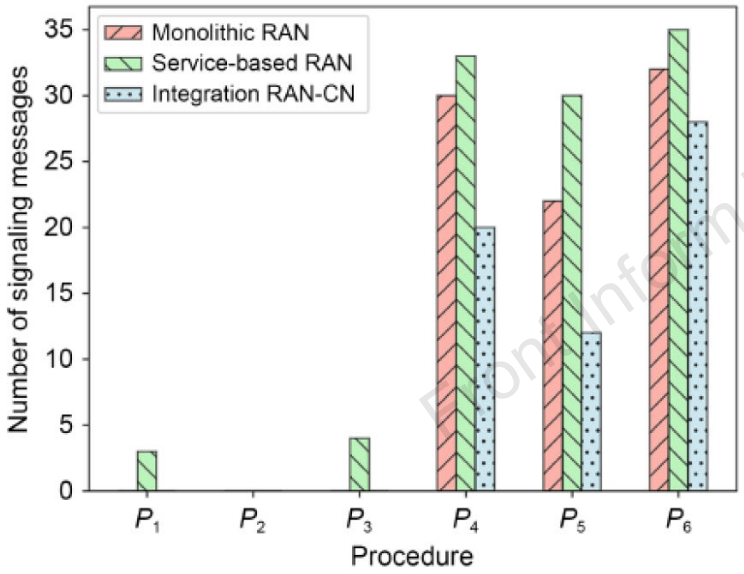

Fig. 13 Number of CP signaling messages (CP: control plane; RAN: radio access network; CN: core network)

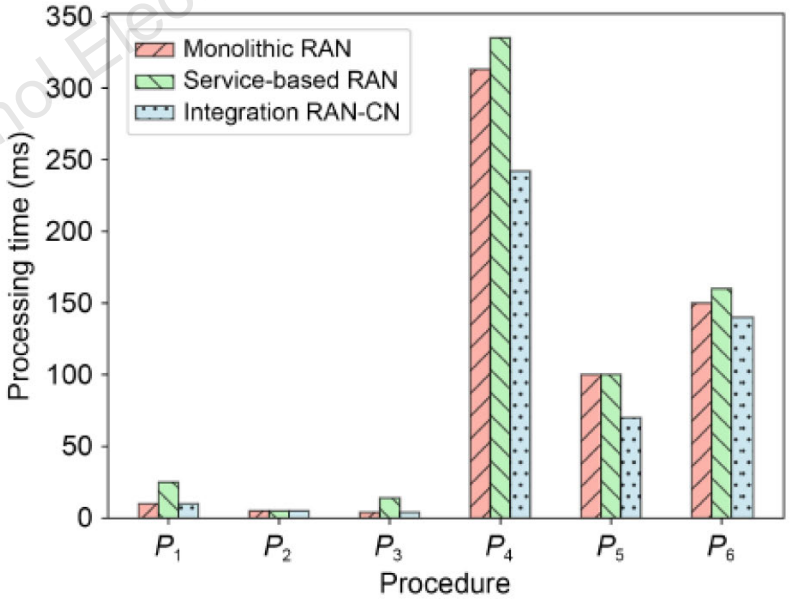

Fig. 14 Processing delay (RAN: radio access network; CN: core network)

Conclusions

1. A virtualization and decoupling service-based RAN architecture can offer an open RAN environment for AI optimization and a customized network.

2.The decoupling of the RAN and the integration decoupling of RAN-CN are clarified by analyzing the protocol stack. A decoupling scheme based on a minimum spanning tree is proposed.

3.The service-based RAN architecture enhances flexibility in handover management and security mechanisms. By decoupling integration, it effectively overcomes the serial signaling bottleneck associated with both processes, thereby eliminating the limitations imposed by the Ng interface.