Use Case Analysis for Computing in the Network

J. Hong, I. Kunze, K. Wehrle, D. Trossen, M.J. Montpetit, X. de Foy, D. Griffin, M. Rio

Reminder

At IETF 117

- The drafting leader changed to Jungha Hong (ETRI)
- Proposed to change the title to **'Research challenges of computing in the network'**
- Planned to make the scope of the draft broader and more generalized

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Categorization of Research Challenges (1/3)

Main Category	Sub Category	Description	Challenges
COIN Fundamentals	-	Define the core principles, objectives, and scope of COIN.	
Enablers to tackle key operational challenges	Enabling store and forward technologies	Store and forward technologies are crucial for handling data packets in a network where data might need to be temporarily stored before being forwarded to its final destination.	- Heterogeneous Network Support
	Transport dynamics	Address the complexities of adapting transport protocols for dynamically deployed computing nodes.	- Optimized Data Transport
	App design for COIN	Delve into unique design considerations for applications operating in the distributed computational nature of COIN.	- Dynamic Resource Allocation - Programming Abstractions - Migration and Flexibility
	Data lifecycle in COIN	From creation to disposal, how is data managed, processed, and safeguarded in a COIN environment?	- State Management
	Routing and topology	Tackle challenges posed by in-network computation on data routing and network topology management.	- Load Balancing
	Industrial integration	Understand the unique challenges and requirements of deploying COIN in industrial settings.	- Latency Concerns

Categorization of Research Challenges (2/3)

Main Category	Sub Category	Description	Challenges
Reliability & Robustness	Fault tolerance	How can COIN systems be designed to handle failures gracefully, ensuring minimal disruptions?	- Fault Tolerance and Reliability
	Scalability concerns	As the network grows, how will COIN systems maintain performance and reliability?	- Scalability
	Performance metrics & Benchmarks	Define and develop benchmarks to evaluate COIN systems' efficiency, speed, and overall performance.	- Evaluation Metrics and Benchmarks
Security, Privacy & Ethics	In-network security threats	Address potential vulnerabilities introduced by computing within the network.	- Security and Privacy Concerns
	Data privacy in COIN	With data processing decentralized, how can user privacy be maintained?	
	Ethical considerations	Understand the societal and individual implications of COIN, especially in contexts like surveillance or personal data processing.	

Categorization of Research Challenges (3/3)

Main Category	Sub Category	Description	Challenges
Interoperability & Legacy Integration	Standardization needs	What standards are essential to ensure widespread adoption and compatibility of COIN solutions?	- Interoperability and Standardization
	Legacy system interactions	Explore challenges and strategies for integrating COIN with older, non-COIN infrastructures.	- Integration with Legacy Systems
Economic & Business Perspectives	Cost-Benefit Analysis:	Research into the economic advantages and potential drawbacks of adopting COIN.	- Energy Efficiency
	Business models for COIN	Explore how businesses can monetize or gain competitive advantage through COIN.	- Economic and Business Models

Research Challenges (1/4)

- **Heterogeneous Network Support:** With COIN, network nodes can have varied computing capabilities. How can COIN solutions cater to networks with mixed computational capabilities, and how can they ensure consistent performance?
- **Dynamic Resource Allocation:** One of the main challenges of COIN would be dynamic allocation of computational resources at the network nodes, especially under different traffic patterns. How can nodes decide which tasks to compute and which ones to forward?
- **Security and Privacy Concerns:** COIN introduces new areas where security breaches can happen. How do we ensure data security, especially when some computations are offloaded to intermediary nodes that might not be fully trusted?
- **Optimized Data Transport:** Given that some computations can happen at the network nodes, how can we design protocols that decide the optimal location for computation versus simple data transport?

Research Challenges (2/4)

- **State Management:** When computational functions are executed inside the network, maintaining state becomes a challenge. How can stateful computations be maintained, migrated, or restored after disruptions?
- **Programming Abstractions:** COIN introduces the need for novel programming models that allow developers to specify where and how their application logic should run within the network.
- **Latency Concerns:** One of the potential benefits of COIN is reduced latency since computation can happen closer to the data source. However, introducing computation within the network can also introduce latency if not managed appropriately. Research would need to determine the balance and identify use cases where latency benefits are maximized.
- **Fault Tolerance and Reliability:** Introducing computation in network nodes necessitates new strategies for fault tolerance. How do we handle node failures, especially during an active computation? How can we ensure data integrity and reliability in such scenarios?

Research Challenges (3/4)

- **Interoperability and Standardization:** As COIN evolves, there will be a need for standard protocols, interfaces, and practices that ensure seamless interoperability between different vendors and devices. Establishing these standards is crucial for widespread COIN adoption.
- **Load Balancing:** With COIN, network nodes will not just handle data but also computational tasks. This introduces a new dimension for load balancing – ensuring that computational tasks are evenly distributed and no node becomes a bottleneck due to computational overhead.
- **Energy Efficiency:** Computation consumes power. Implementing computation at every network node can increase the overall energy consumption of the network. Research would need to find efficient algorithms and hardware solutions to keep the energy costs minimal.
- **Scalability:** As networks grow, ensuring that COIN can scale efficiently without compromising performance or increasing complexity becomes a significant challenge. Solutions would need to be scalable both in terms of network size and computational demand.

Research Challenges (4/4)

- **Migration and Flexibility:** Given the dynamic nature of network loads, there could be scenarios where active computations might need to be migrated from one node to another. How can this be achieved seamlessly without data loss or excessive latency?
- **Economic and Business Models:** From an economic perspective, how do we model the costs associated with COIN? How do ISPs and cloud providers bill their customers when computation is distributed across the network? New business models might emerge, considering the shift from traditional networking.
- **Evaluation Metrics and Benchmarks:** As with any new technology, standardized benchmarks and evaluation metrics will be needed to gauge the performance, efficiency, and suitability of COIN solutions for various applications.
- **Integration with Legacy Systems:** A significant number of existing networks and systems might not be ready for COIN. How can these legacy systems be integrated or upgraded to support COIN without significant disruptions or costs?

Future plans

- Any comments are welcome!
- Reflect comments on the new direction of drafting the document
- Submit the updated draft, draft-irtf-coinrg-use-case-analysis-02 with the title, ‘Research challenges of computing in the network’
- **Need more co-authors** to move this draft forward
  - Eve Schooler joined as co-author

Thank you!