NDNファンクションチェインを用いた情報指向サービスメッシュの実装と評価

Performance Evaluations of NDN-based Information-Centric Service Mesh

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Outline

- Introduction
  - Research Background
  - Research Purpose
  - Related Works
- Proposed Method
  - Information-Centric Service Mesh
  - Proposed Models
- Evaluation
  - Scenario
  - Results
- Summary
  - Conclusion
  - Future Works

Research Background

Beyond 5G / 6G

[1]

Ultra low power consumption

Autonomy

Scalability

Ultra safe, Resiliency

- All devices work together autonomously
- The network immediately makes itself optimal

Service Mesh

Orchestrating virtualized small functions

Service Function Chaining

Virtually chaining functions on a network

Offering autonomous integration of networking and computing

[1] Ministry of Internal Affairs and Communications, "Beyond 5G 推進戦略 - 6G へのロードマップ-," 2020. https://www.soumu.go.jp/main_content/000696613.pdf

Problems

Service Mesh

Service Function Chaining

Based on **Host-oriented** IP network

Problems [2]

Dynamic Routing

Scalability

Information-Centric Networking

Data-oriented decentralized network architecture

[2] K. Kanai, T. Tsuda, H. Nakazato, and J. Katto, "Information centric service mesh for autonomous in-network computing," in Proceedings of the 9th ACM Conference on Information-Centric Networking, ser. ICN '22. New York, NY, USA: Association for Computing Machinery, 2022, p. 159–161. [Online]. Available: https://doi-org.waseda.idm.oclc.org/10.1145/3517212.3559481

Problems

Service Mesh

Information-Centric Networking

Information-Centric Service Mesh

Dynamic Routing

Name-based routing will be effective

Scalability

Decentralized architecture will be effective

Network function disaggregation of IC-SM still needs to be clarified

Research Purpose

To propose models of decentralized service mesh using ICN and clarify optimal network function disaggregation.
To evaluate proposed models on the virtual network.

Service Mesh

Information-Centric Networking

Information-Centric Service Mesh

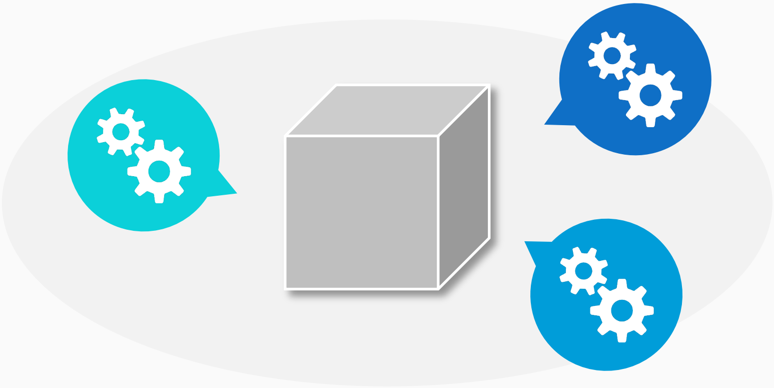
Related Work

Service Mesh

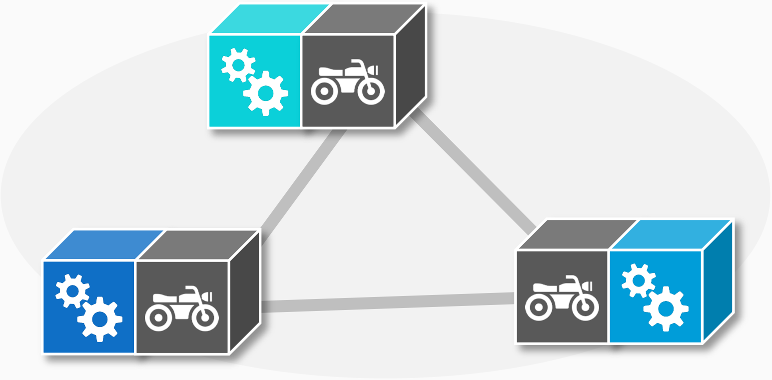
[3]

- Applications are constructed by services that are divided into smaller functional units（**Microservice**）
- Sidecar provides the communication mechanism among microservices

Monolithic Architecture



Service Mesh

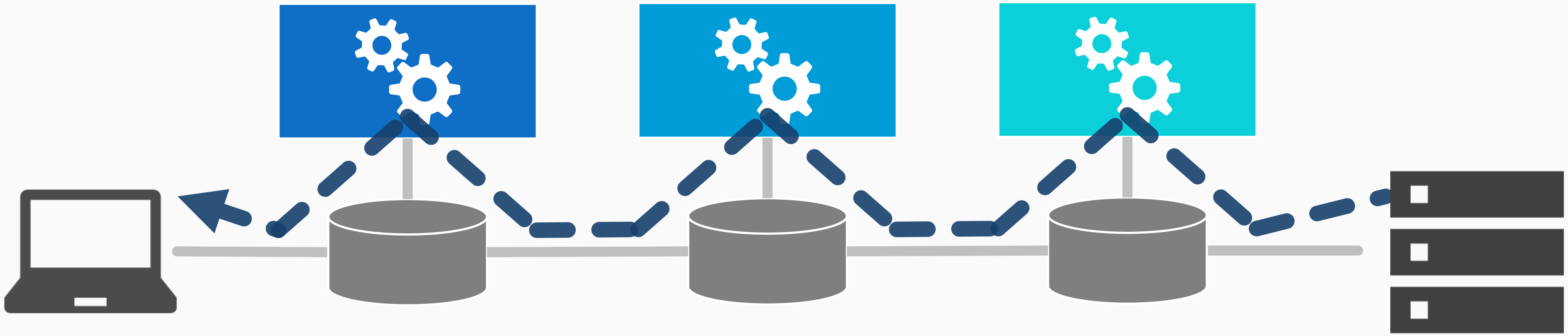


[3] R.Sharma,GettingStartedwithIstioServiceMesh[electronicresource] : Manage Microservices in Kubernetes / by Rahul Sharma, Avinash Singh., 1st ed. Berkeley, CA: Apress, 2020.

Related Work

Service Function Chaining (SFC)

- Controls the routing of packets with contents so that they are routed through appropriate functions [4]
- Virtually chaining functions on a network



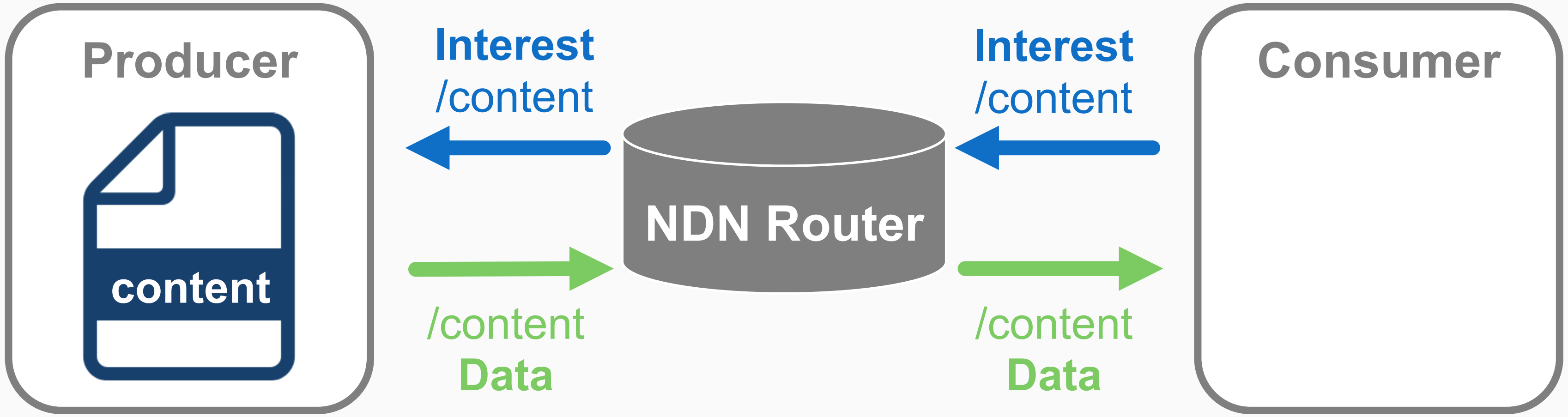
[4] S. Raynovich "What Is Service Function Chaining? Definition," 2016, [Online]. Available: https://www.sdxcentral.com/sdn/network-virtualization/definitions/whatis-network-service-chaining/

Related Work

Information-Centric Networking (ICN)

[5]

- Requests content by name
- **NDN** (Named Data Networking) is a type of ICNs
- Communicates with **Interest Packet** and **Data Packet**



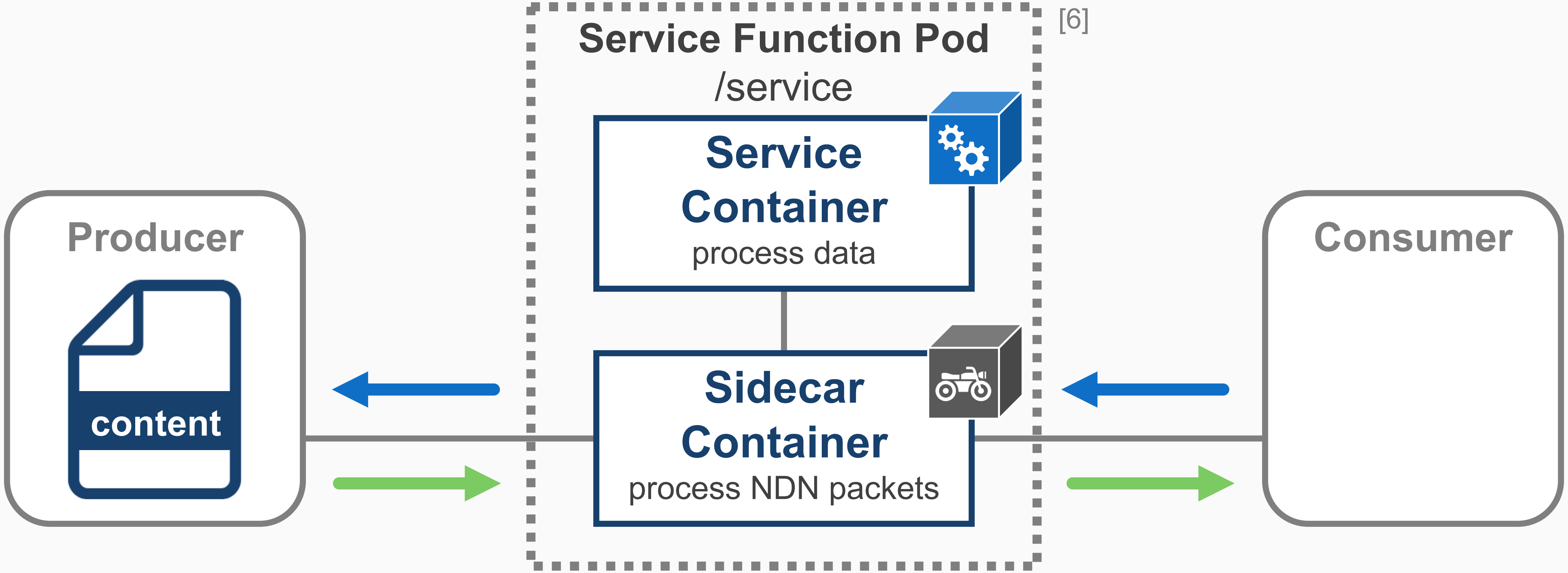
[5] "Named Data Networking." [Online]. Available: https://named-data.net

Information-Centric Service Mesh (IC-SM)

Service Mesh

ICN

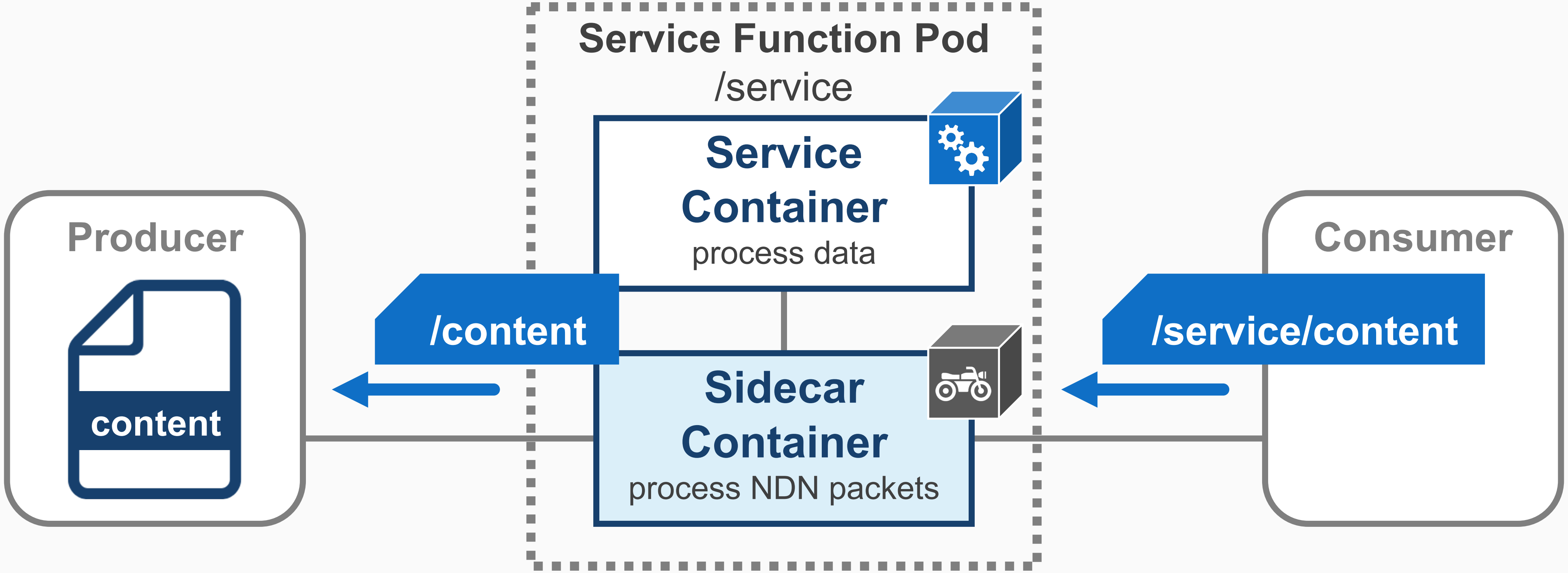
IC-SM



[6] H. Saito, Y. Bando, K. Kanai, and H. Nakazato, “Performance evaluations of ICN service mesh using NDN function chaining,” IEICE, Technical Report vol. 122, no. 397, CS2022-85, pp. 71-76, March 2023, (in Japanese).

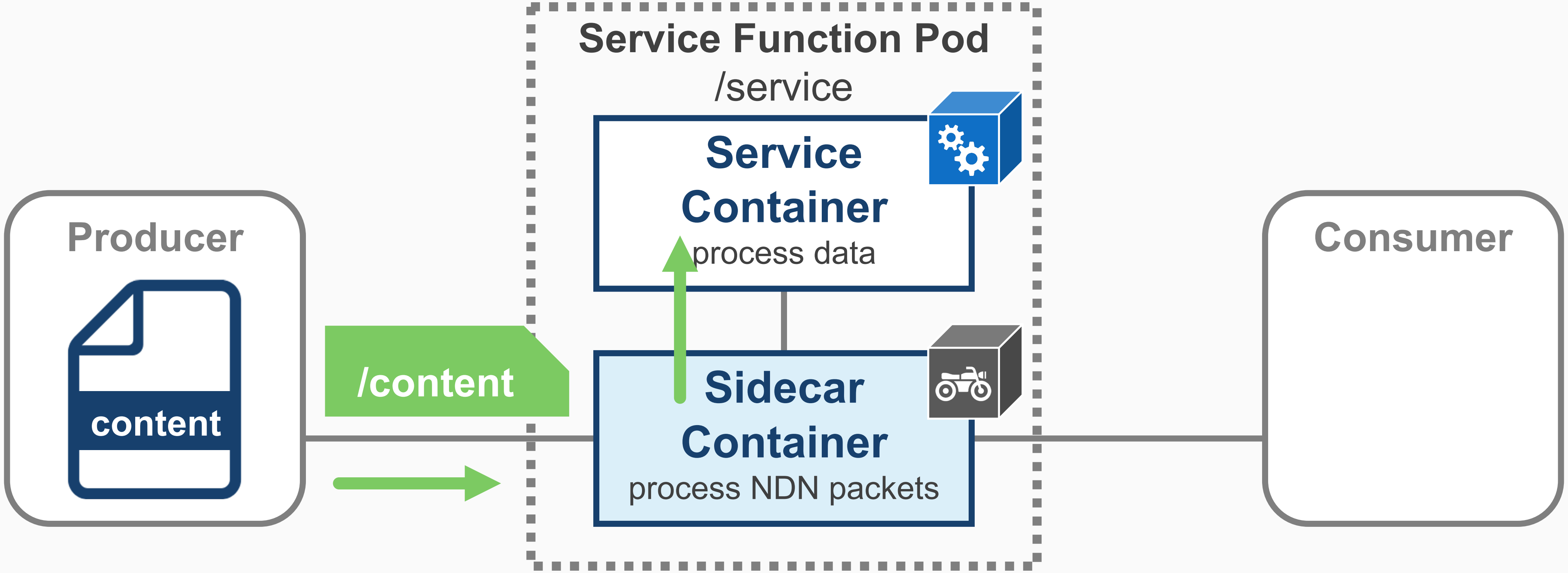
Information-Centric Service Mesh (IC-SM)

SFC Flow



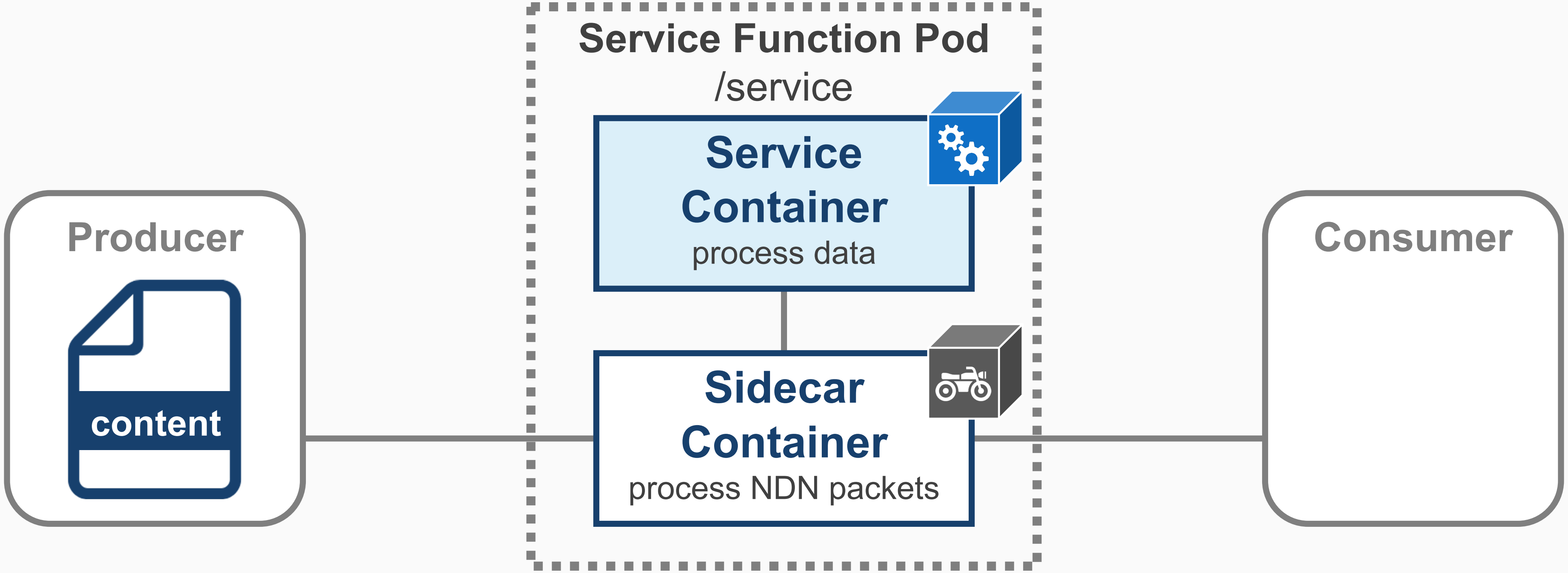
Information-Centric Service Mesh (IC-SM)

SFC Flow



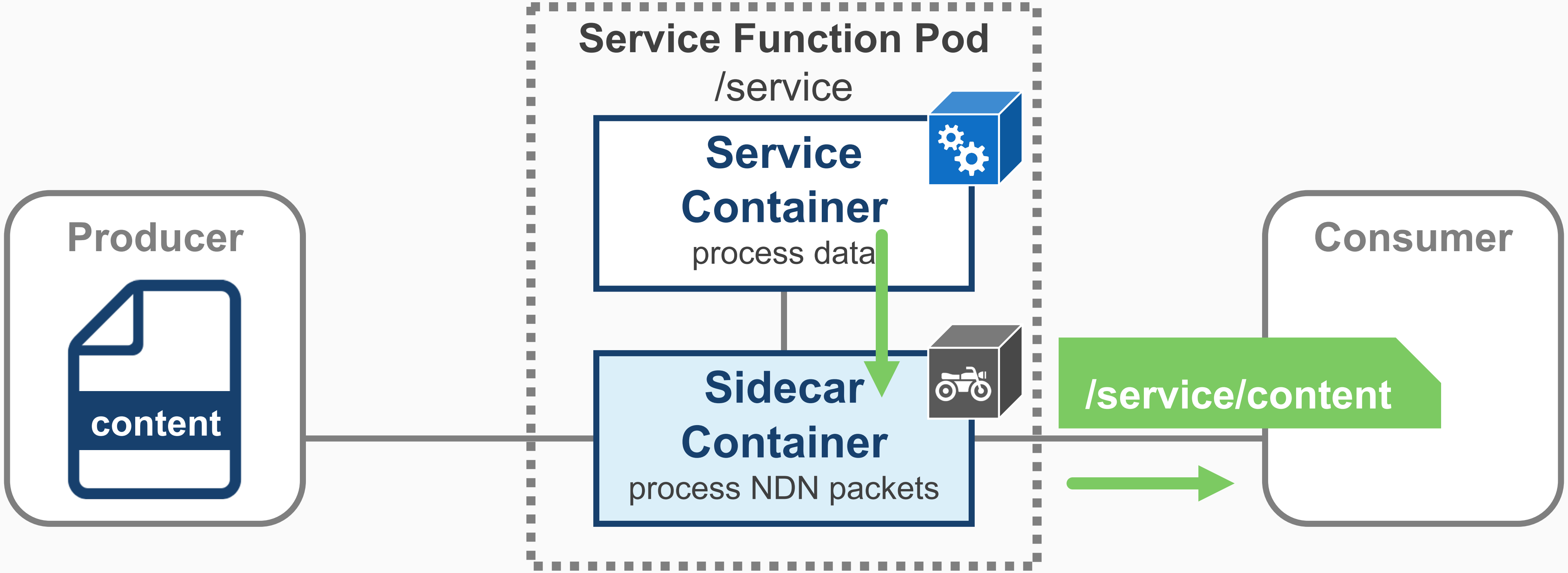
Information-Centric Service Mesh (IC-SM)

SFC Flow

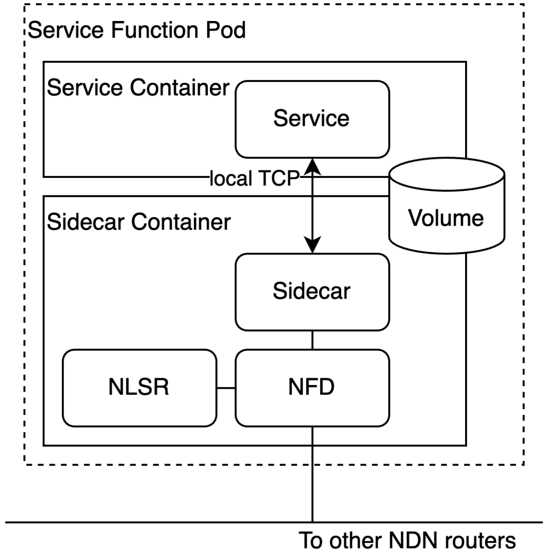


Information-Centric Service Mesh (IC-SM)

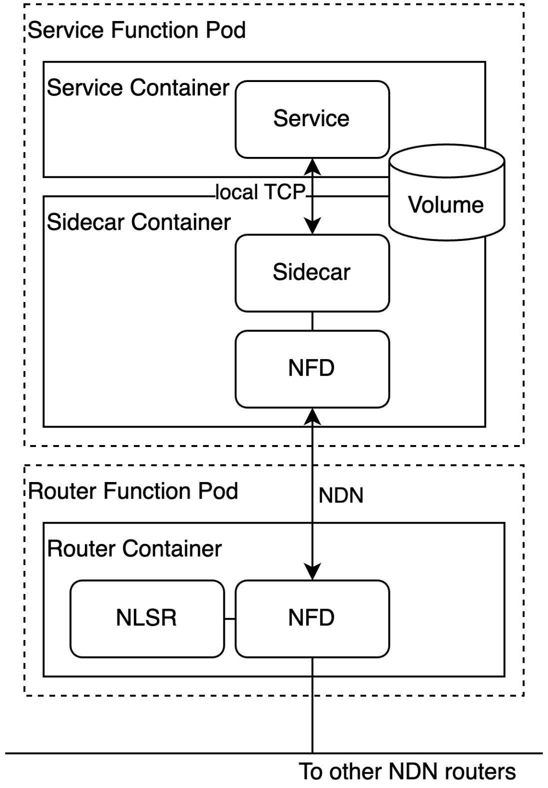
SFC Flow



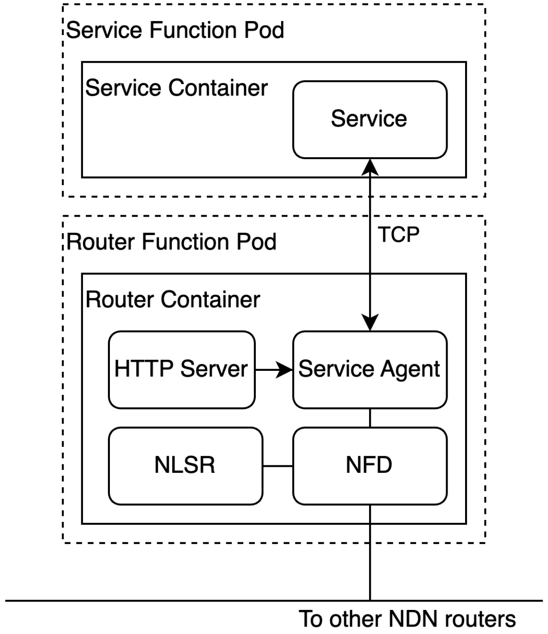
Proposal Models



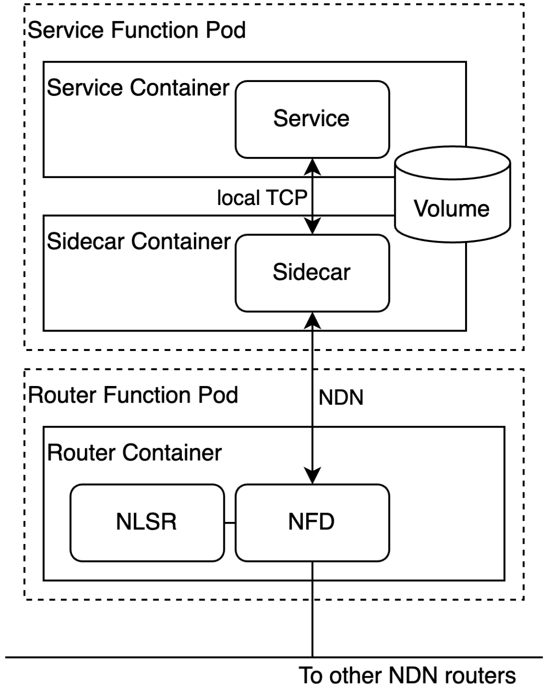
Basic Arch.



Router Arch.

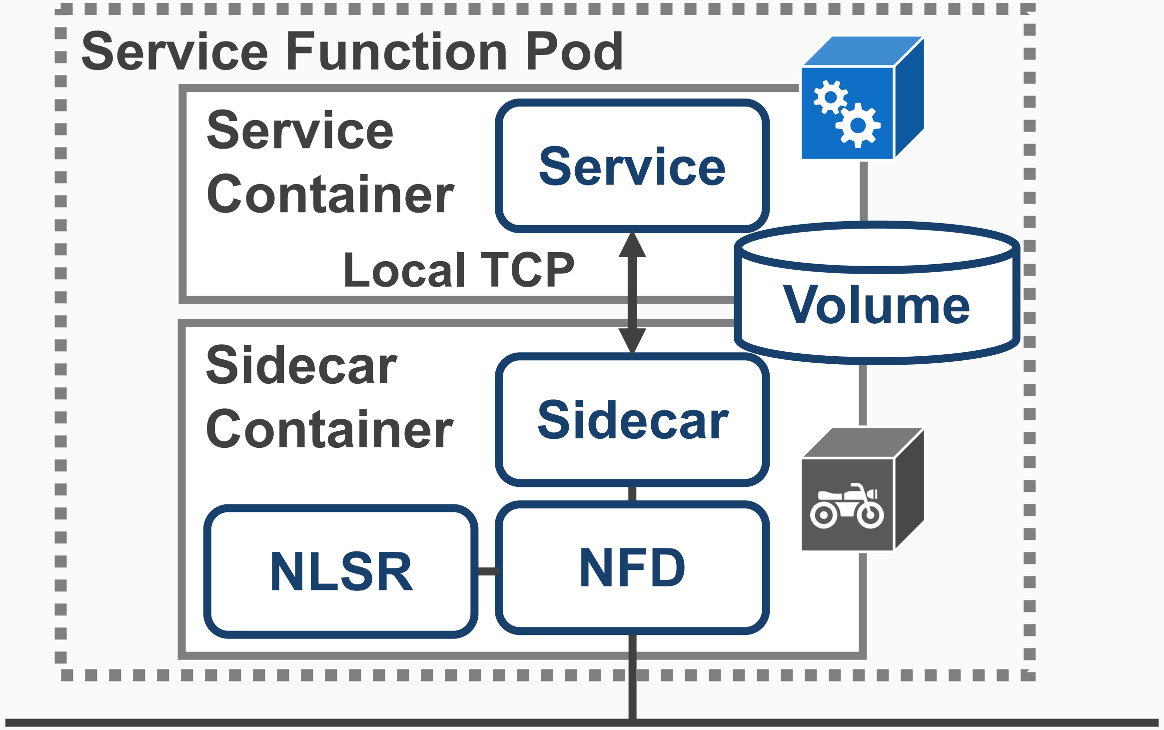


Service Agent Arch.



Sharing NFD Arch.

Basic Arch. (BA)



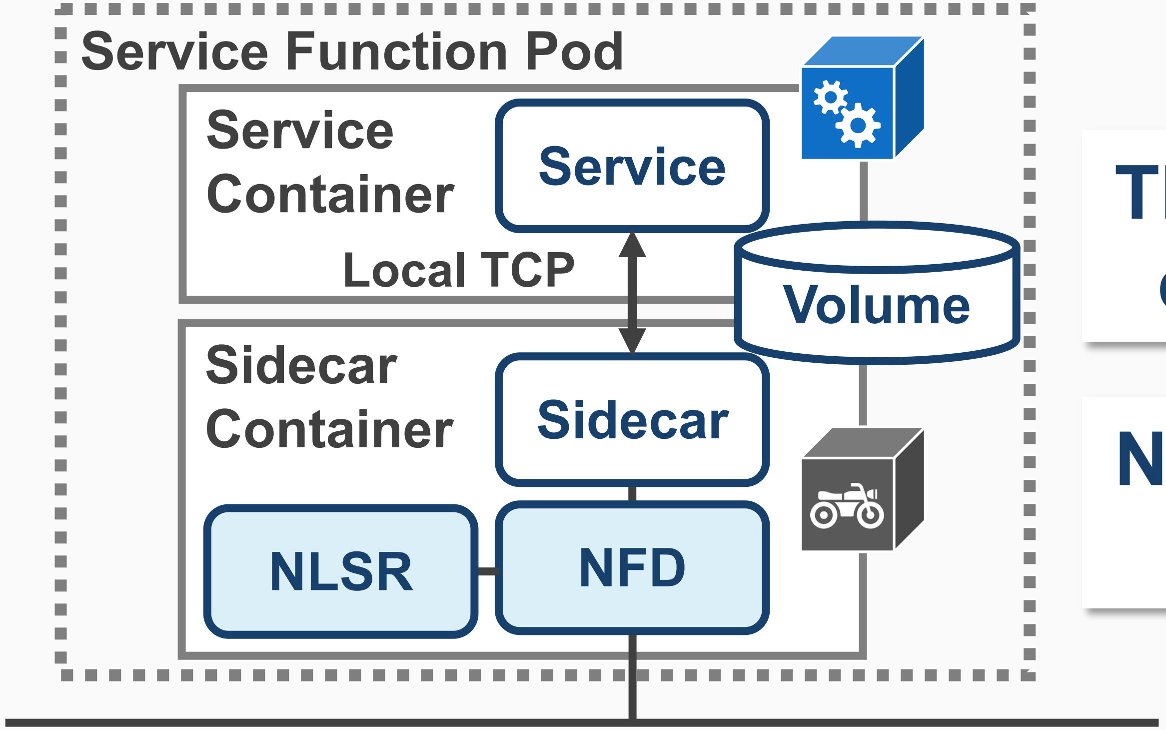
Functional Blocks (FB)

Service	executes function
NLSR	routes NDN router
Sidecar	processes Interest name joins data chunks
NFD	forwards NDN packets

* **NDN router** = NFD managed by NLSR

[6] H. Saito, Y. Bando, K. Kanai, and H. Nakazato, "Performance evaluations of ICN service mesh using NDN function chaining," IEICE, Technical Report vol. 122, no. 397, CS2022-85, pp. 71-76, March 2023, (in Japanese).

Problems of BA



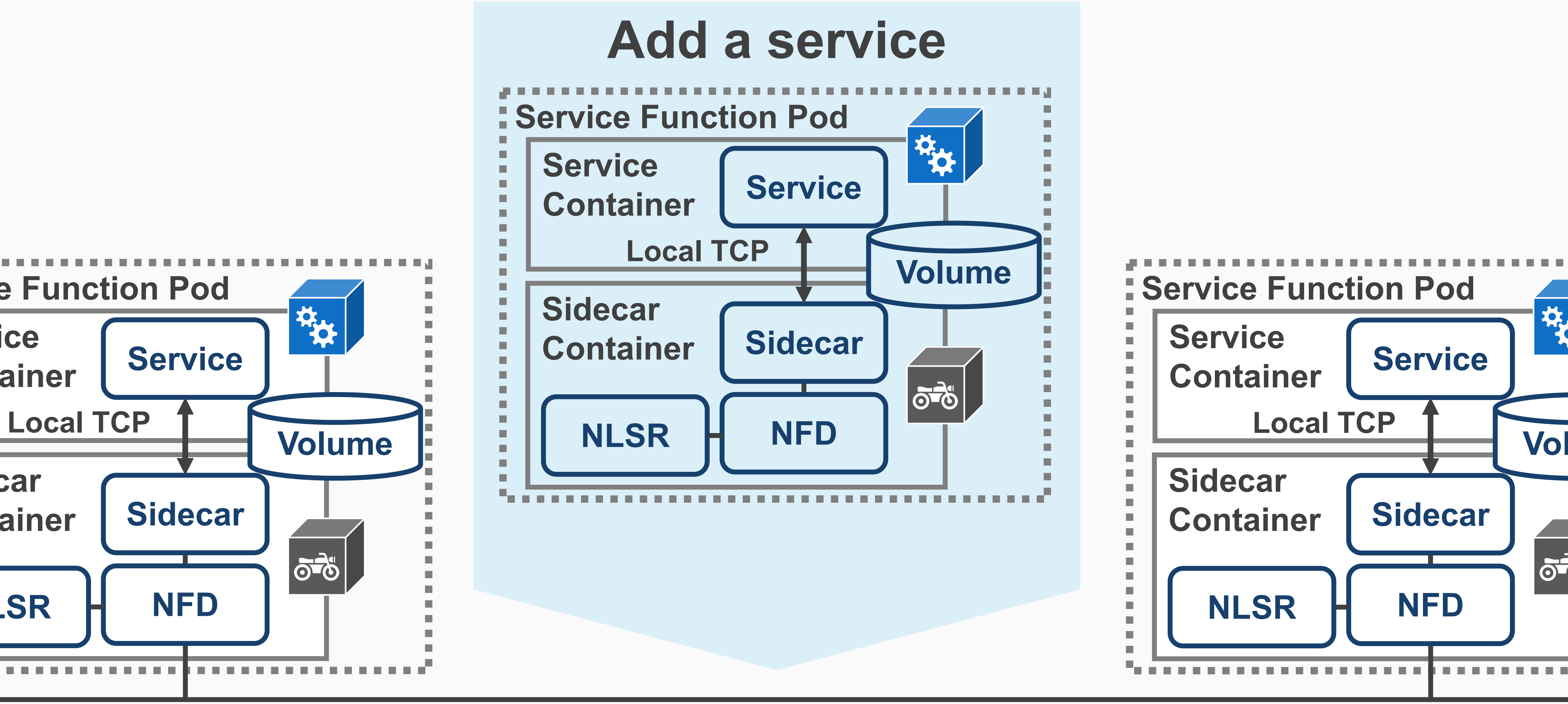
Sidecar container contains NLSR

The num of NDN routers increases every time adding a new service

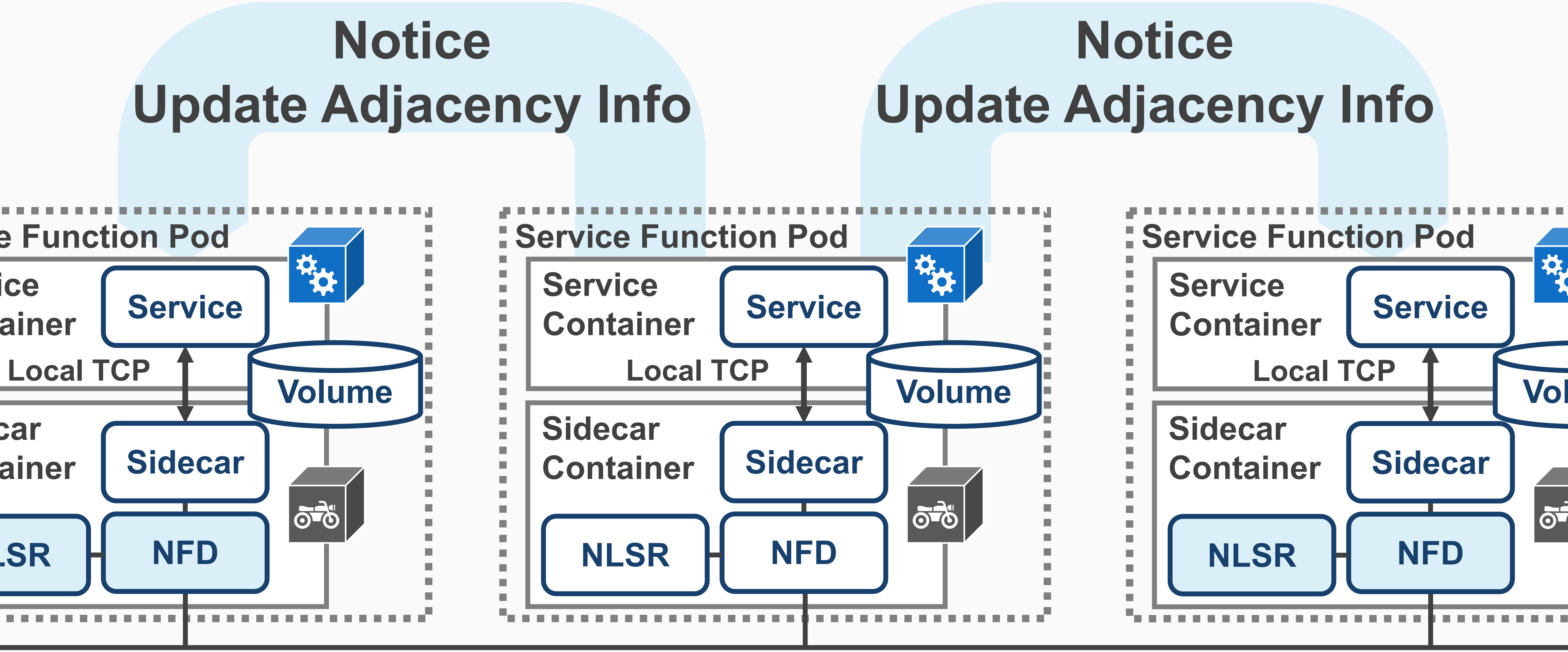
Notification of nearby NDN routers is needed

[6] H. Saito, Y. Bando, K. Kanai, and H. Nakazato, "Performance evaluations of ICN service mesh using NDN function chaining," IEICE, Technical Report vol. 122, no. 397, CS2022-85, pp. 71-76, March 2023, (in Japanese).

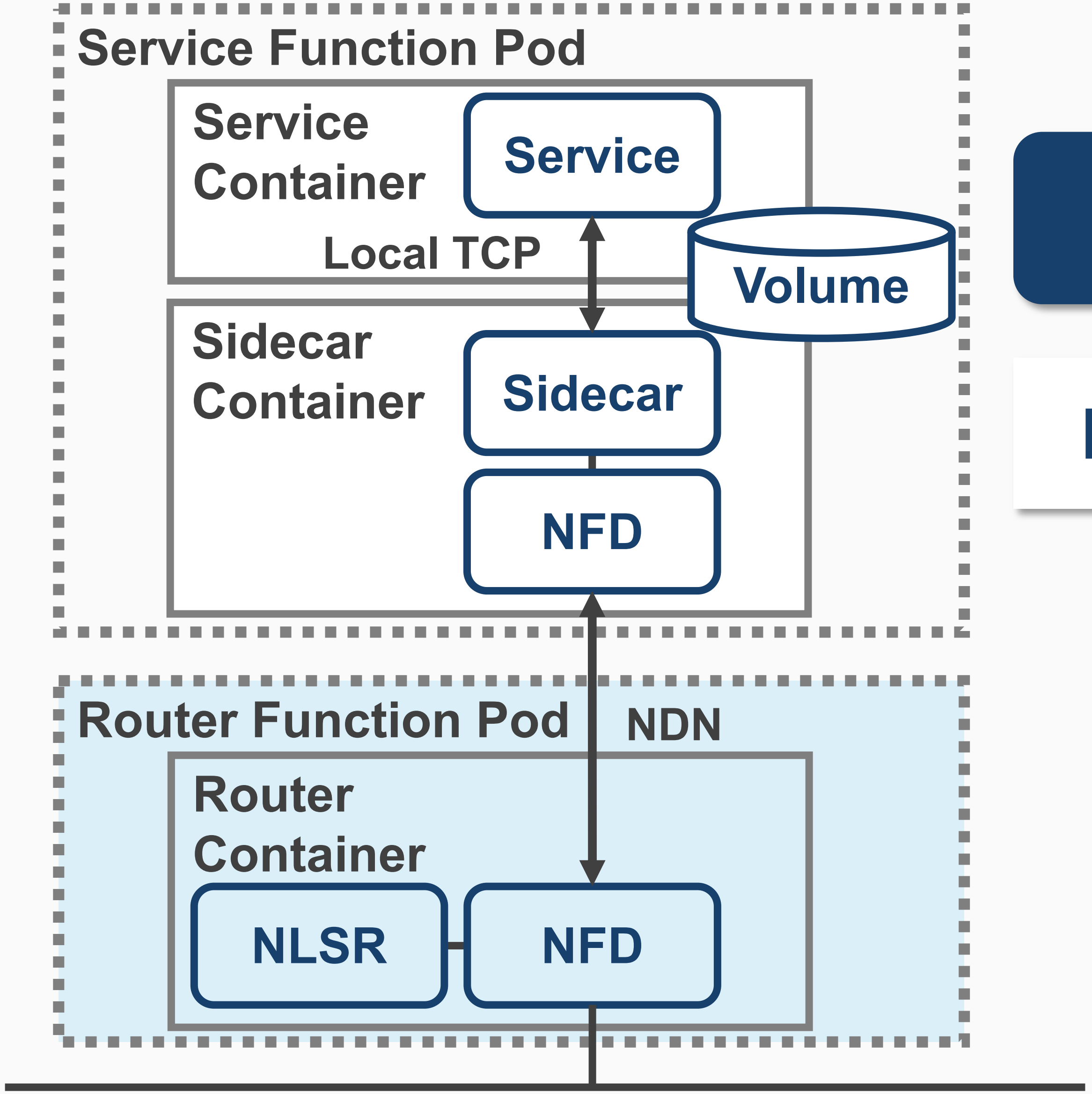
Problems of BA



Problems of BA



Router Arch. (RA)



Router Function Pod

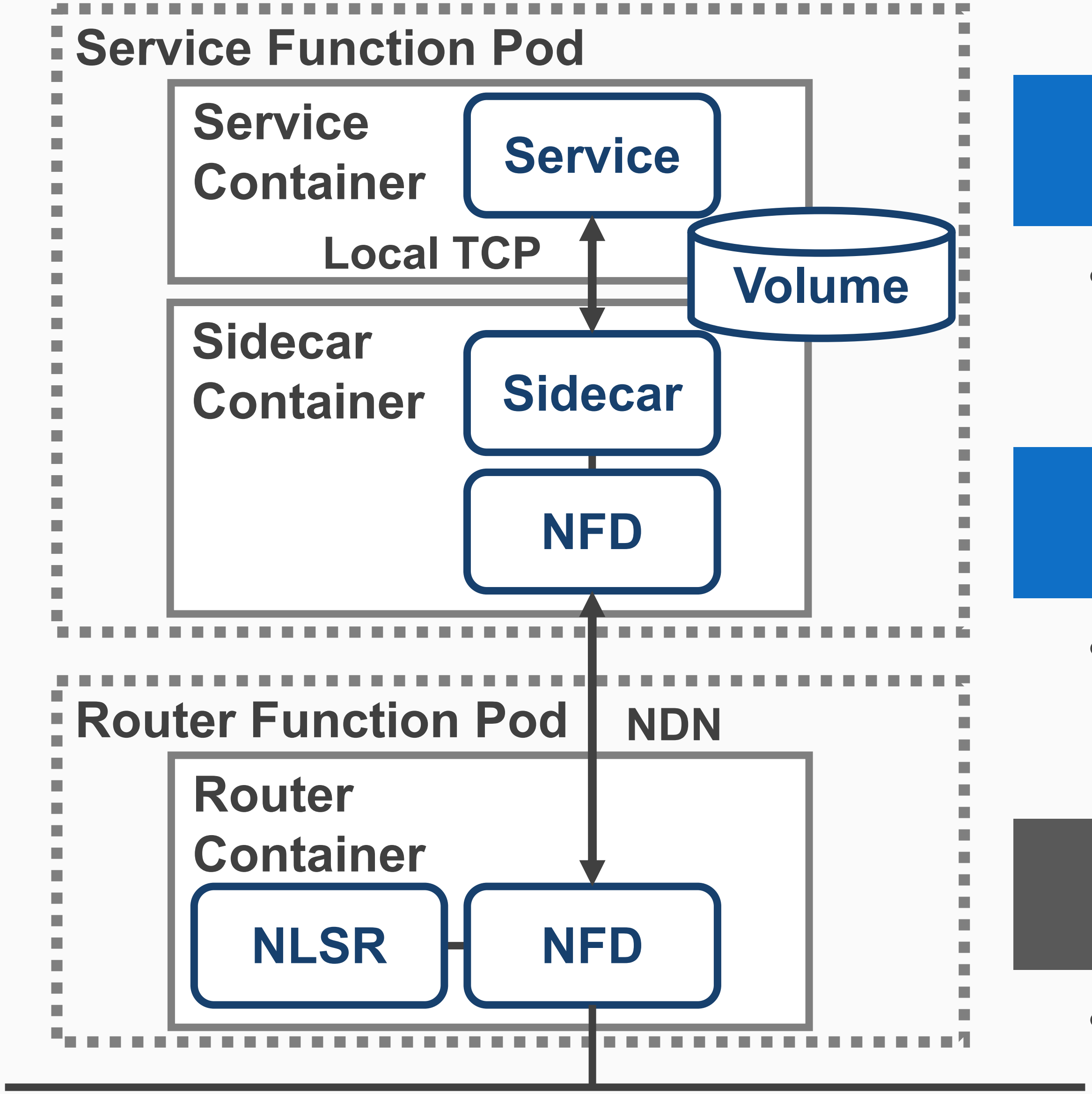
Router container contains NLSR

forwards to **the NFD in the Router container**

routes the NDN router

forwards NDN packets

Router Arch. (RA)



Easy to add services

- Connects to the network through a router function pod

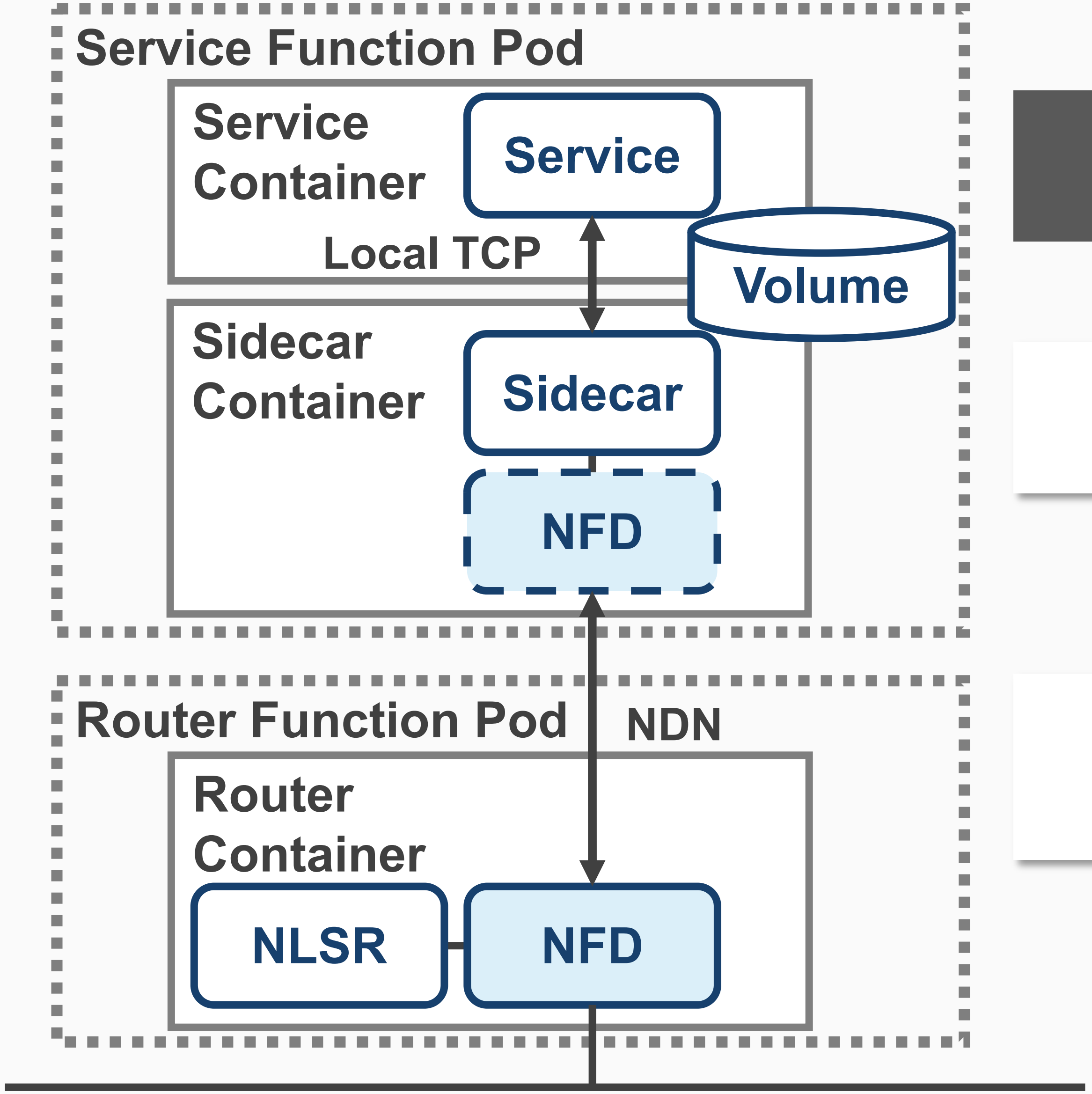
Reduces routing load

- Reduces the number of NDN routers

Increasing number of NFDs

- Requires Router Function Pod

RA Improvements

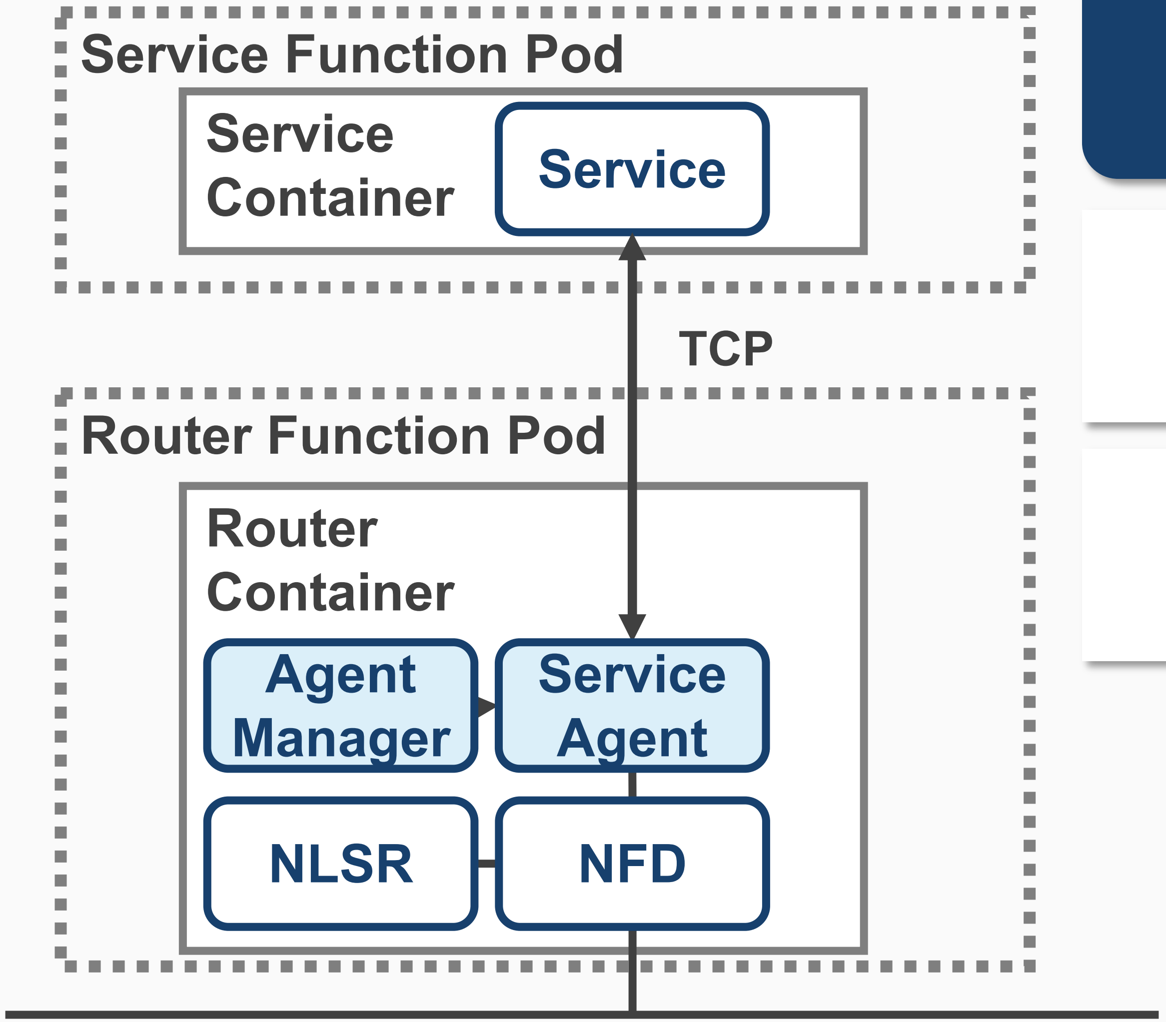


Increasing number of NFDs

Duplicate NFDs

Removes the NFD in the Sidecar Container

Service Agent Arch. (SAA)



Removes the NFD in the Sidecar container

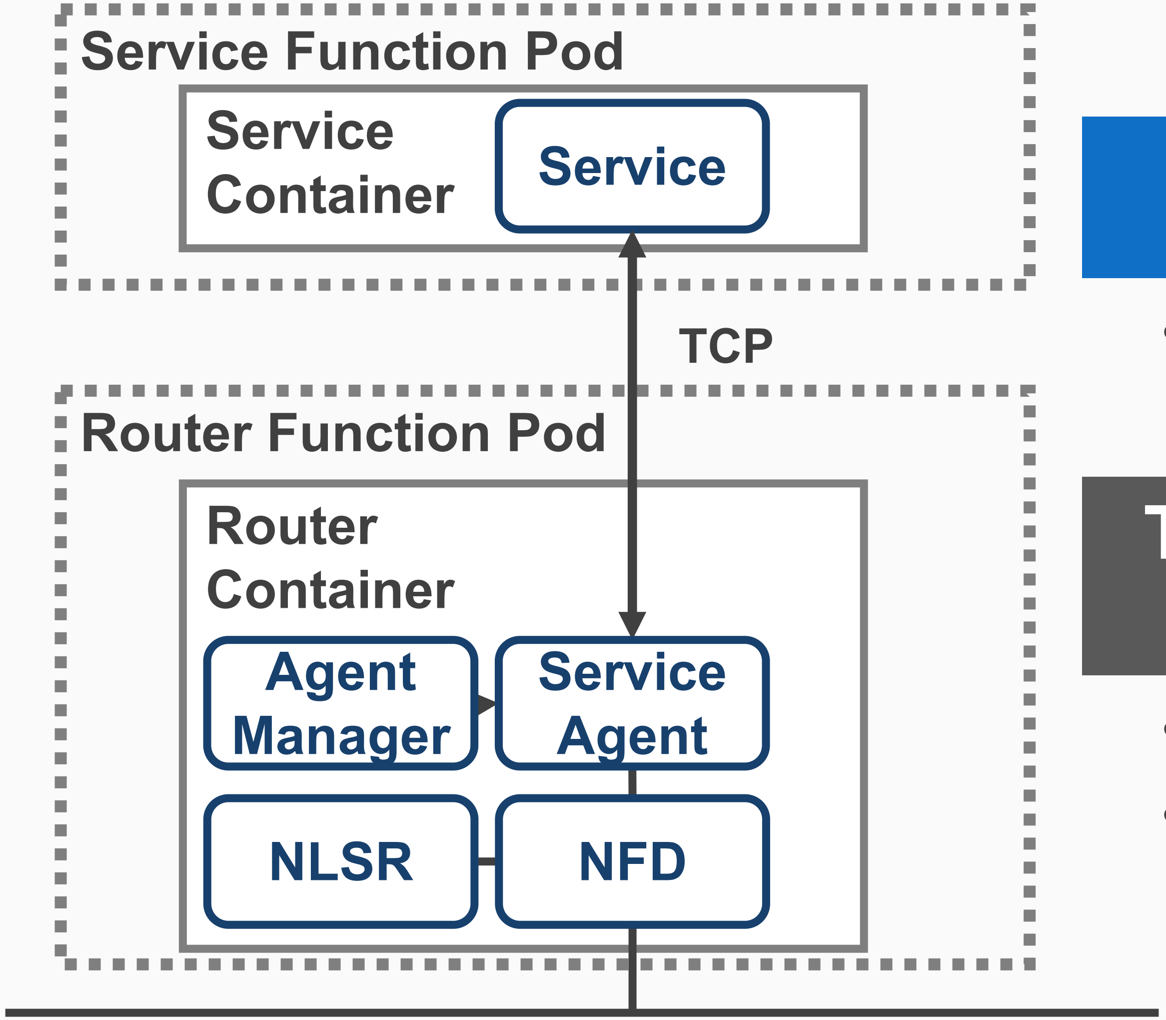
Move Sidecar into the Router Container as Service Agent

Agent Manager creates Service Agent

Agent Manager manages services

Service Agent same role as Sidecar

Service Agent Arch. (SAA)



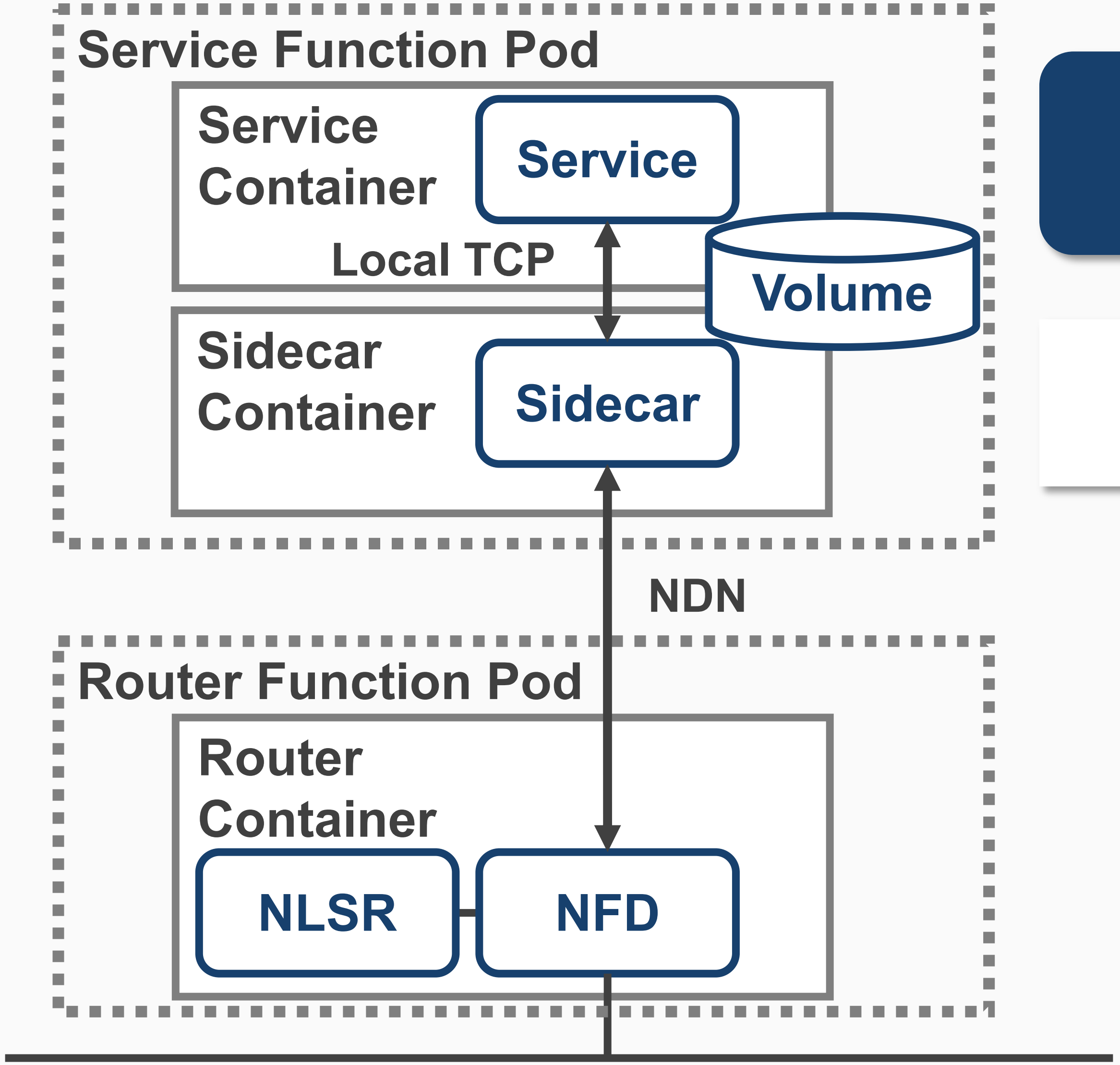
Reduces the number of NFDs

- Moves Sidecar FB into the Router Container

The load on the Router container increases

- Requires Agent Manager
- A Service Agent FB is required for each service

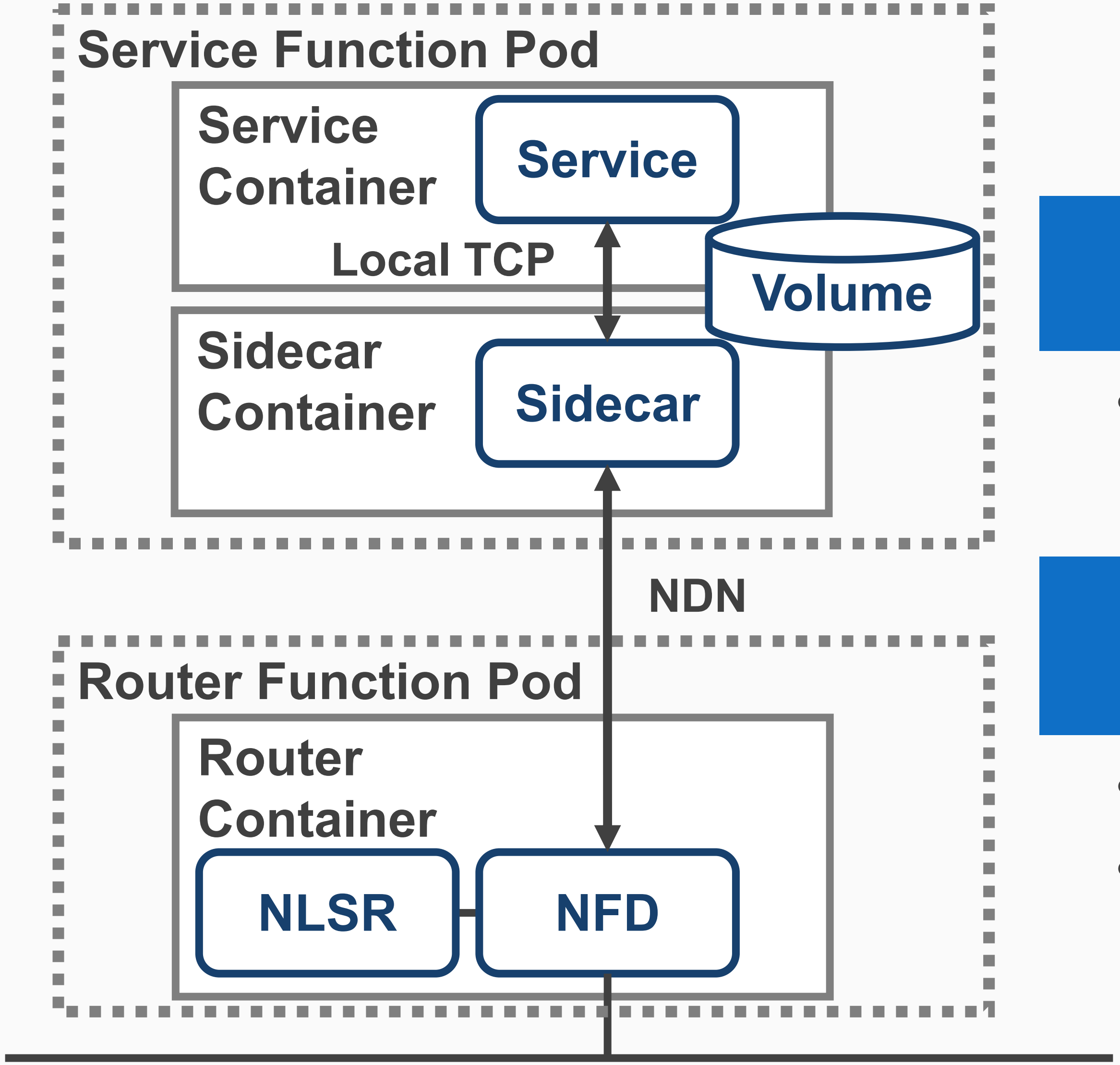
Sharing NFD Arch. (SNA)



Removes the NFD in the Sidecar container

Uses the NFD in the Router container

Sharing NFD Arch. (SNA)



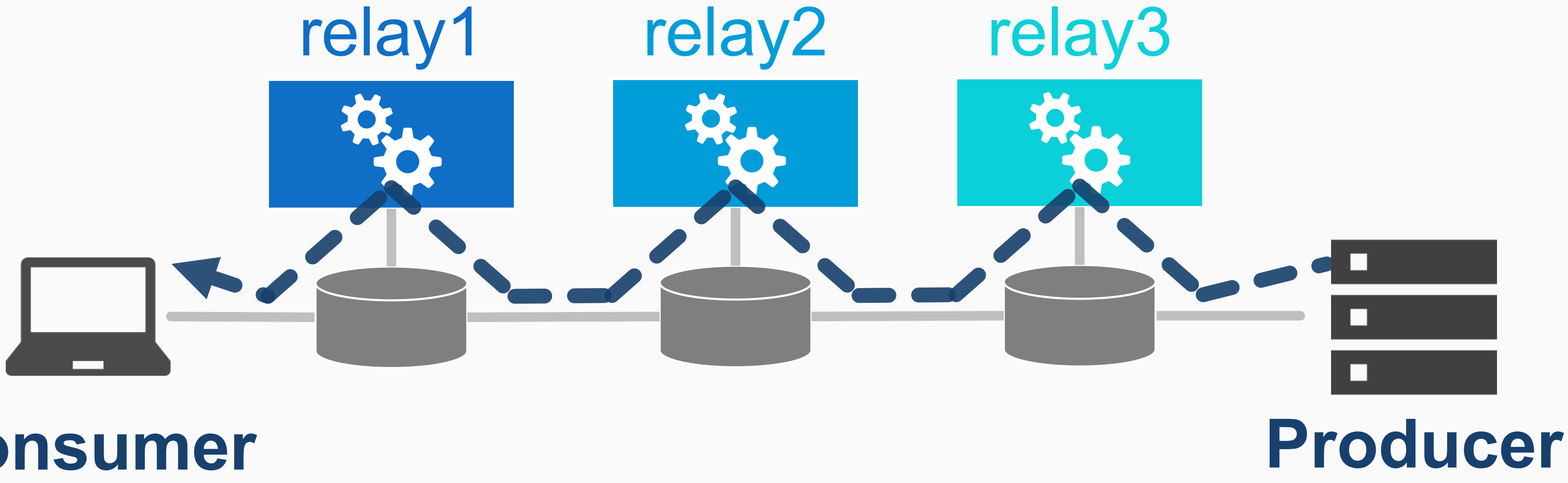
Reduces the number of NFDs

- Removes the NFD in the Sidecar container

Reduces the load on the Router container

- No need for an Service Manager
- Sidecar FB runs in a Sidecar container

Evaluation

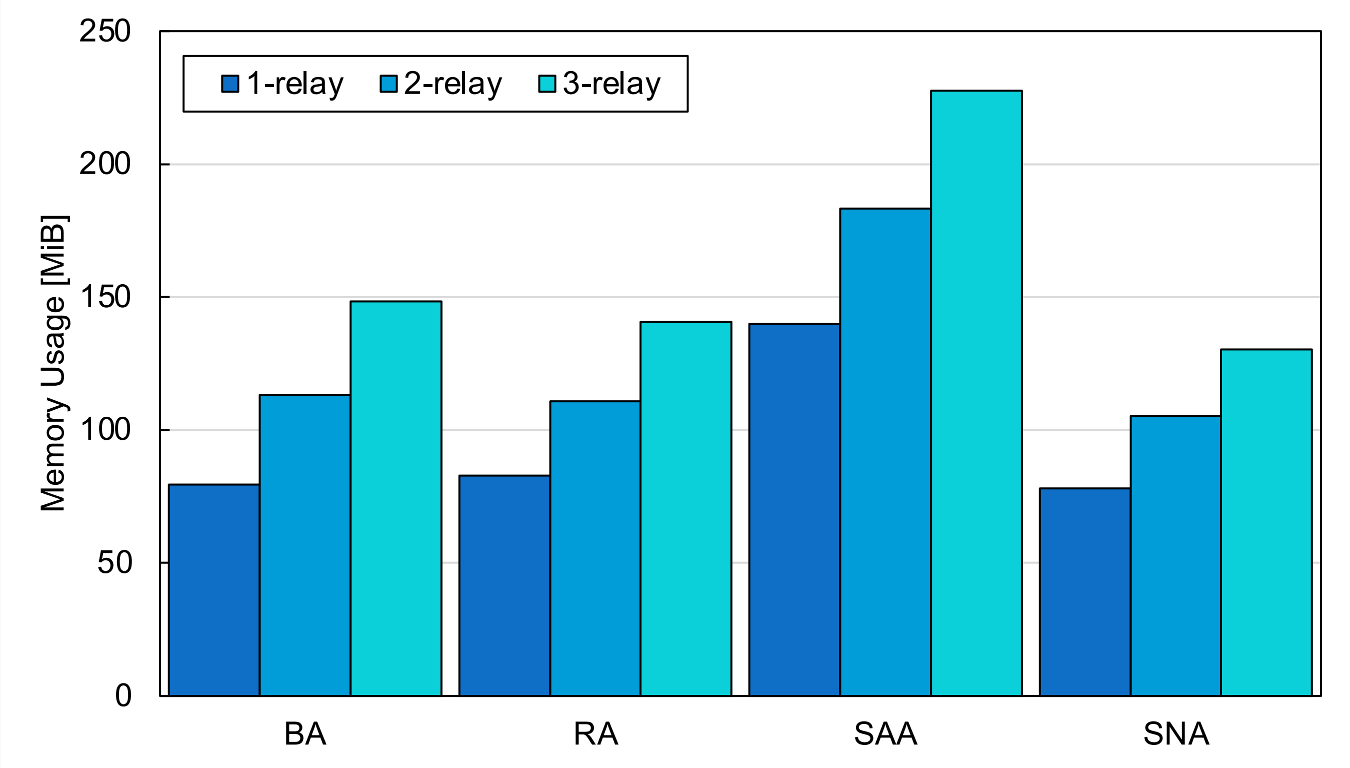


Content Size	**10.76** MB
Request Interval	**10** seconds
Number of Requests	**10**
NFD Cache Size * To measure memory usage	**0**
Allocated CPU * To isolate resource between pods	**1 for each pod**

Measurement Parameters
- **Service Memory Usage**
- **Content Retrieval Time**

Results

Memory Usage



SNA is smallest

- Share the NFD of the Router container

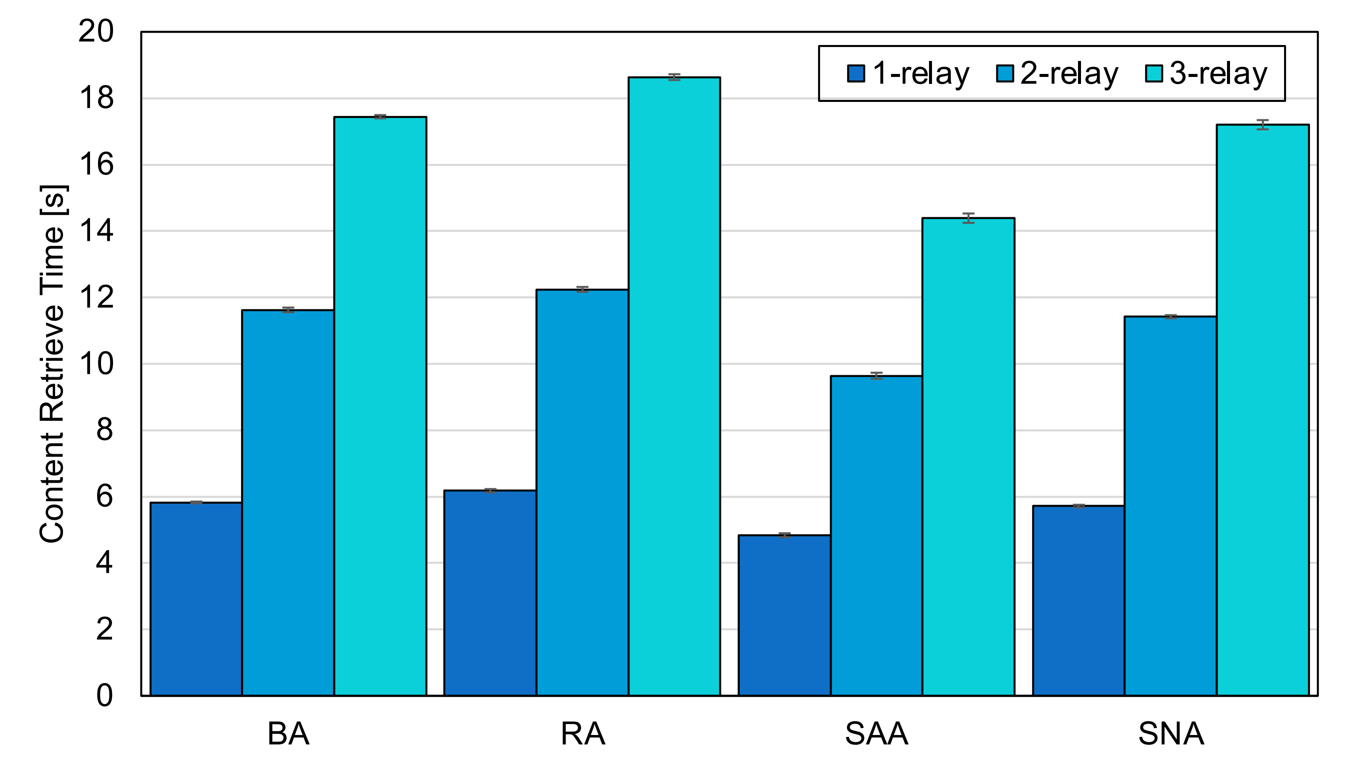
SAA is largest

- Service Manager runs in the Router container

SNA can reduce memory usage

Results

Content Retrieval Time



SAA is smallest

- TCP is faster than NDN

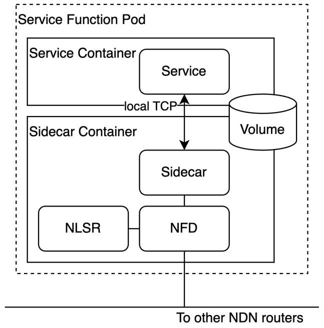
RA is largest

- Increasing number of NFDs
- Time to search for NFD data structures

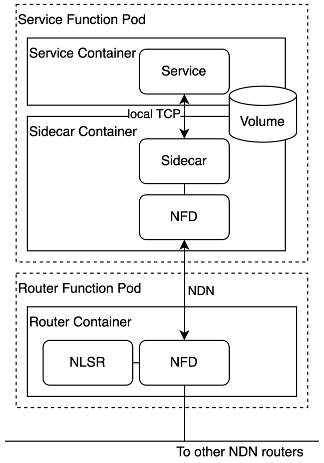
SAA can reduce end-to-end latency

Conclusion

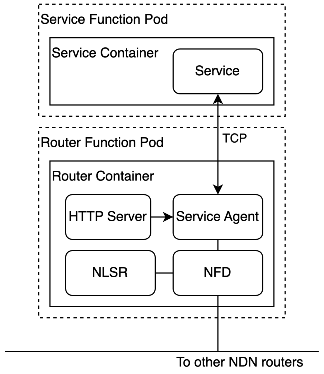
We proposed Four IC-SM Models



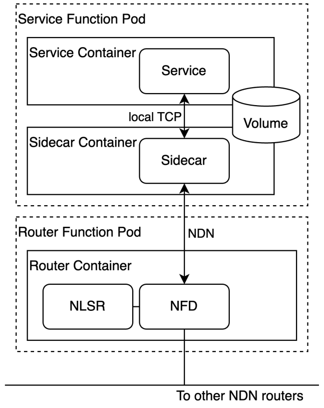
BA



RA



SAA



SNA

The Number of NDN Routers Reduced

End-End Latency Reduced

Memory Usage Reduced

Future Work

Performance Monitoring

Trace Facility

→ **Autonomous Management**

Practical Application

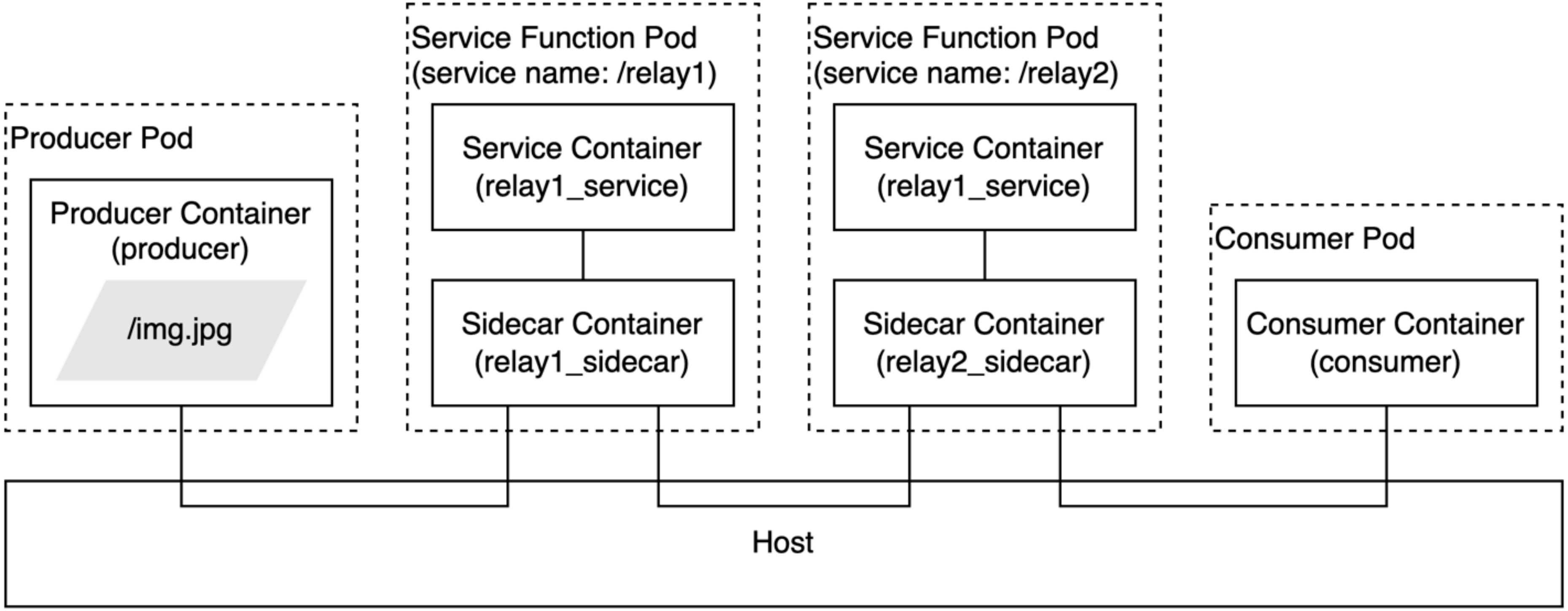
→ **Practical Performance Evaluation**

Acknowledgement

This work was partially supported by NICT, Grant Number 05601, Japan.

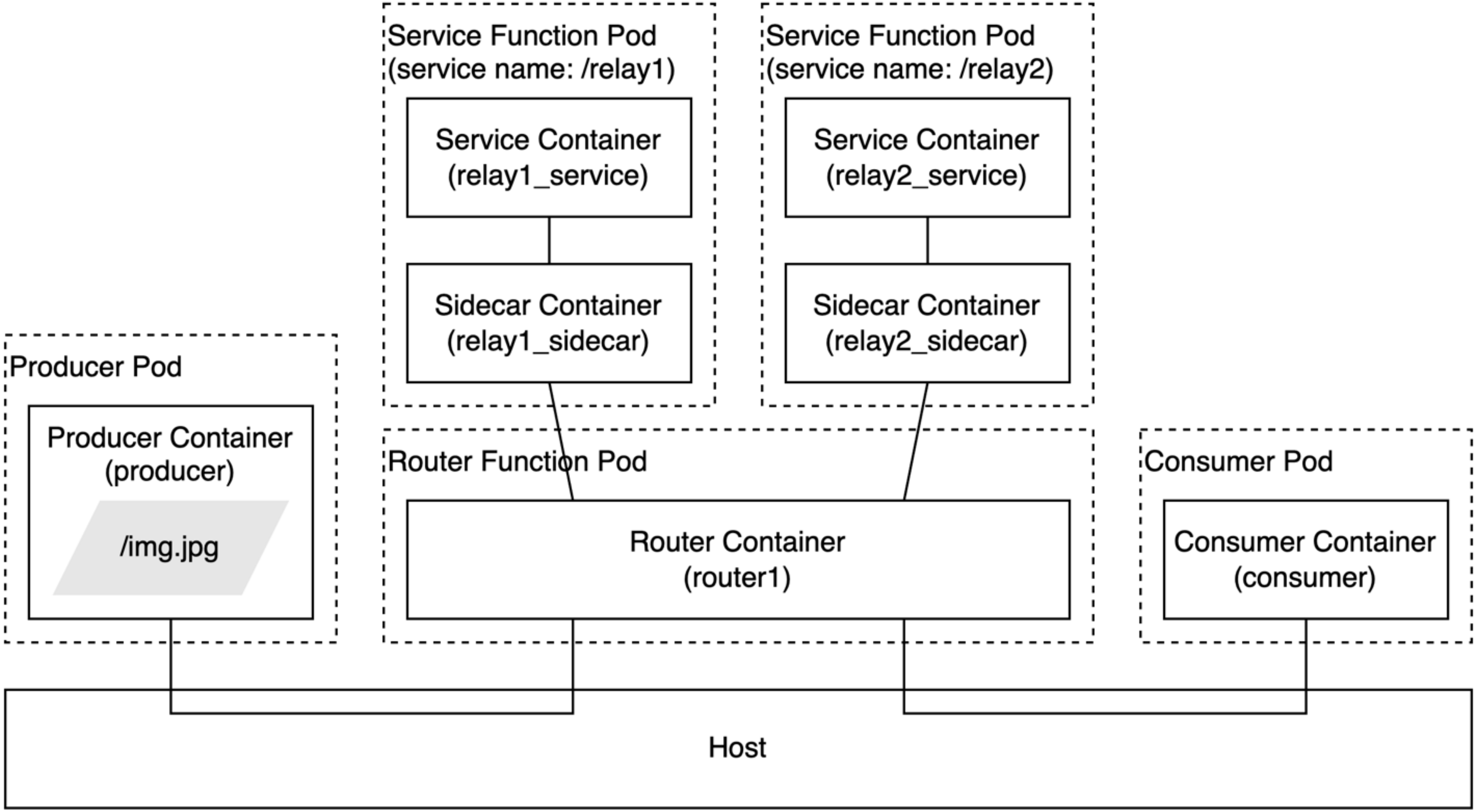
APPENDIX

Evaluation



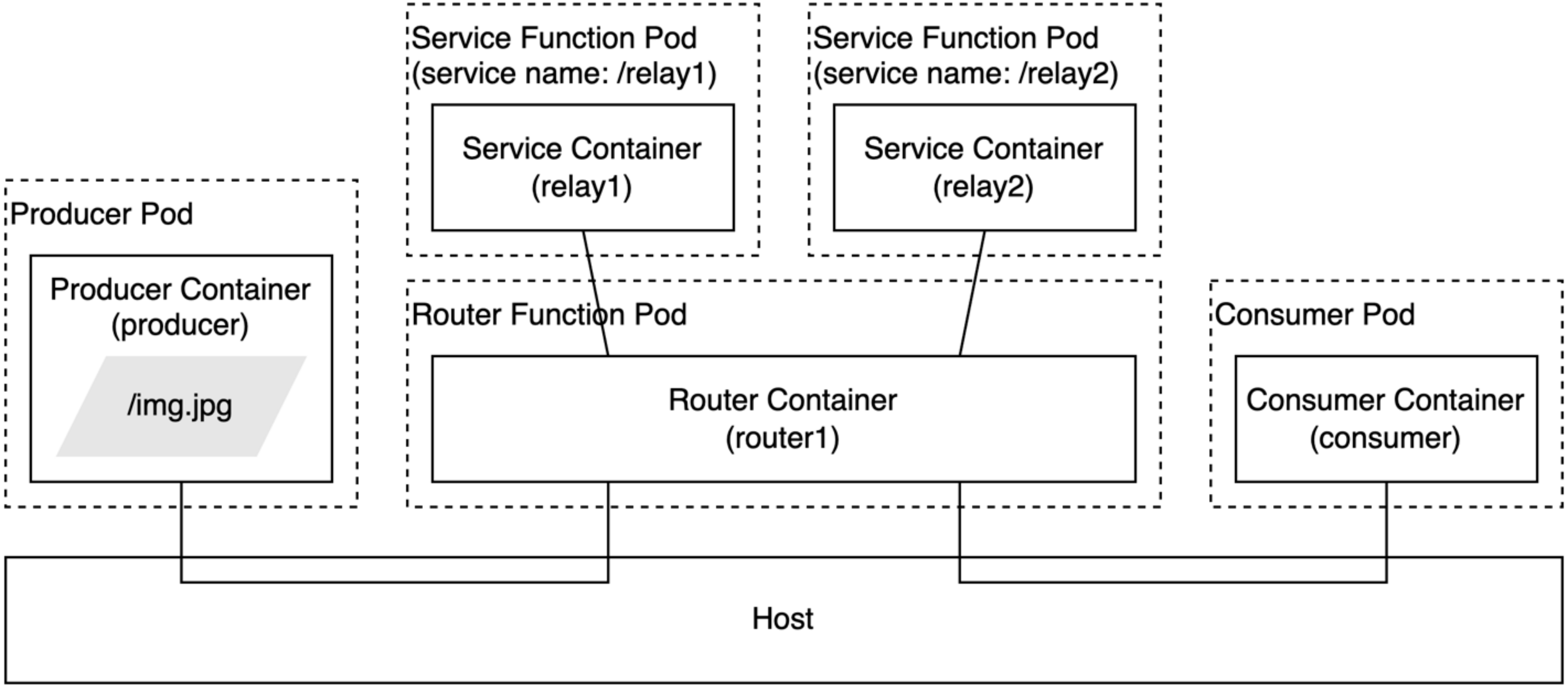
2-relay topology using Basic Architecture

Evaluation



2-relay topology using Router Architecture or Sharing NFD Architecture

Evaluation



2-relay topology using Service Agent Architecture

Results

メモリ使用量の内訳 (2-relay)