Advantages of Multi-Path Transport
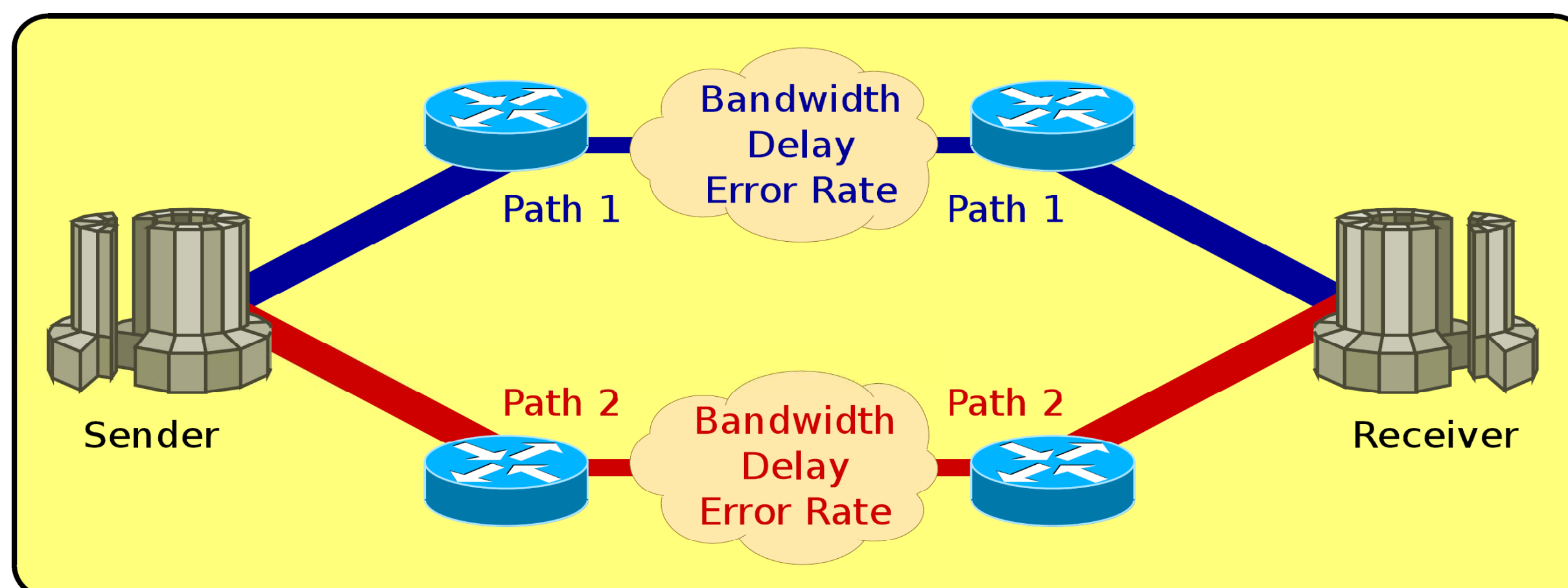
- Increase fault tolerance
- Improve resilience
- Increase bandwidth
- Increase efficiency
- Supplier diversity of networks

Sender — Path 1 — Bandwidth Delay Error Rate — Path 1 — Receiver
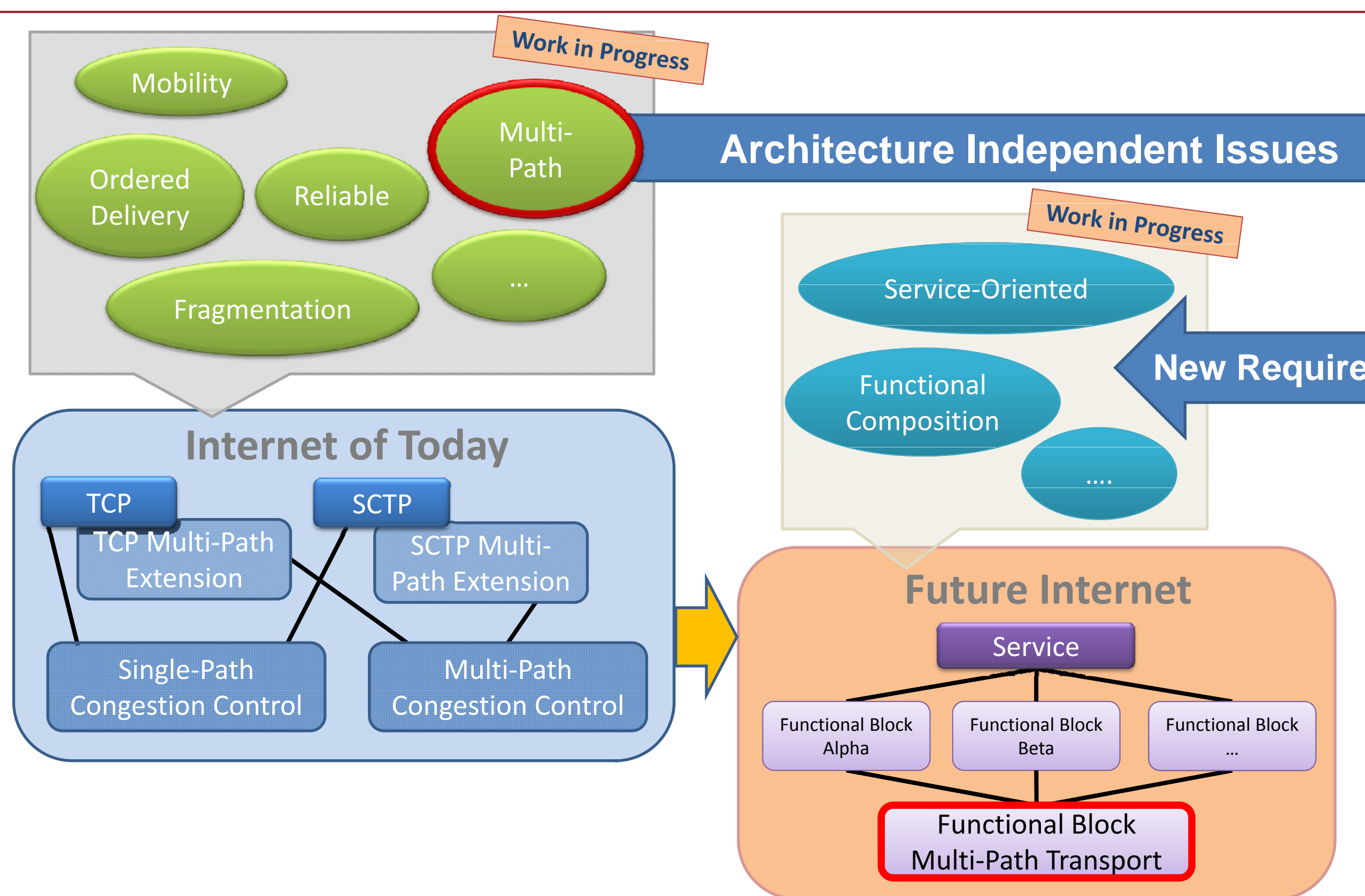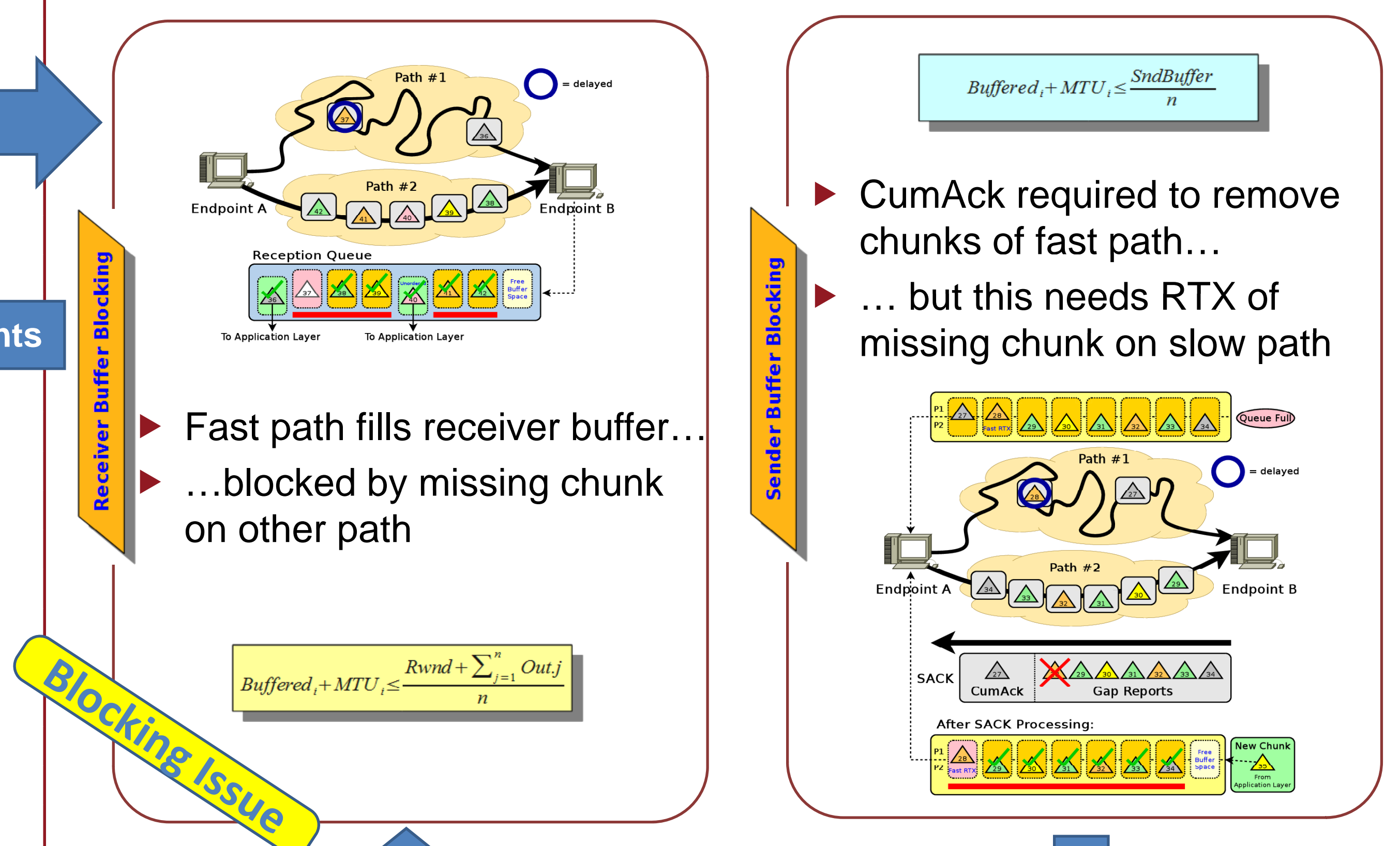Path 2 — Bandwidth Delay Error Rate — Path 2

Ultimate Goal for the Future Internet

Provide full featured

Multi-Path Transport for

Network Services

(Based on Functional Composition Approach)

Solution Approach

Mobility

Ordered Delivery · Reliable

Multi-Path — Work in Progress

Fragmentation · ...

Internet of Today

TCP · SCTP

TCP Multi-Path Extension · SCTP Multi-Path Extension

Single-Path Congestion Control · Multi-Path Congestion Control

Architecture Independent Issues →

Work in Progress

Service-Oriented

Functional Composition

....

← **New Requirements**

Future Internet

Service

Functional Block Alpha · Functional Block Beta · Functional Block ...

Functional Block Multi-Path Transport

"Buffer Blocking" as Example

Receiver Buffer Blocking

Endpoint A — Path #1 — Path #2 — Endpoint B
Reception Queue
To Application Layer · To Application Layer

- Fast path fills receiver buffer…
- …blocked by missing chunk on other path

$$Buffered_i + MTU_i \le \frac{Rwnd + \sum_{i=1}^{n} Out.j}{n}$$

Blocking Issue

Sender Buffer Blocking

$$Buffered_i + MTU_i \le \frac{SndBuffer}{n}$$

- CumAck required to remove chunks of fast path…
- … but this needs RTX of missing chunk on slow path

Endpoint A — Path #1 — Path #2 — Endpoint B
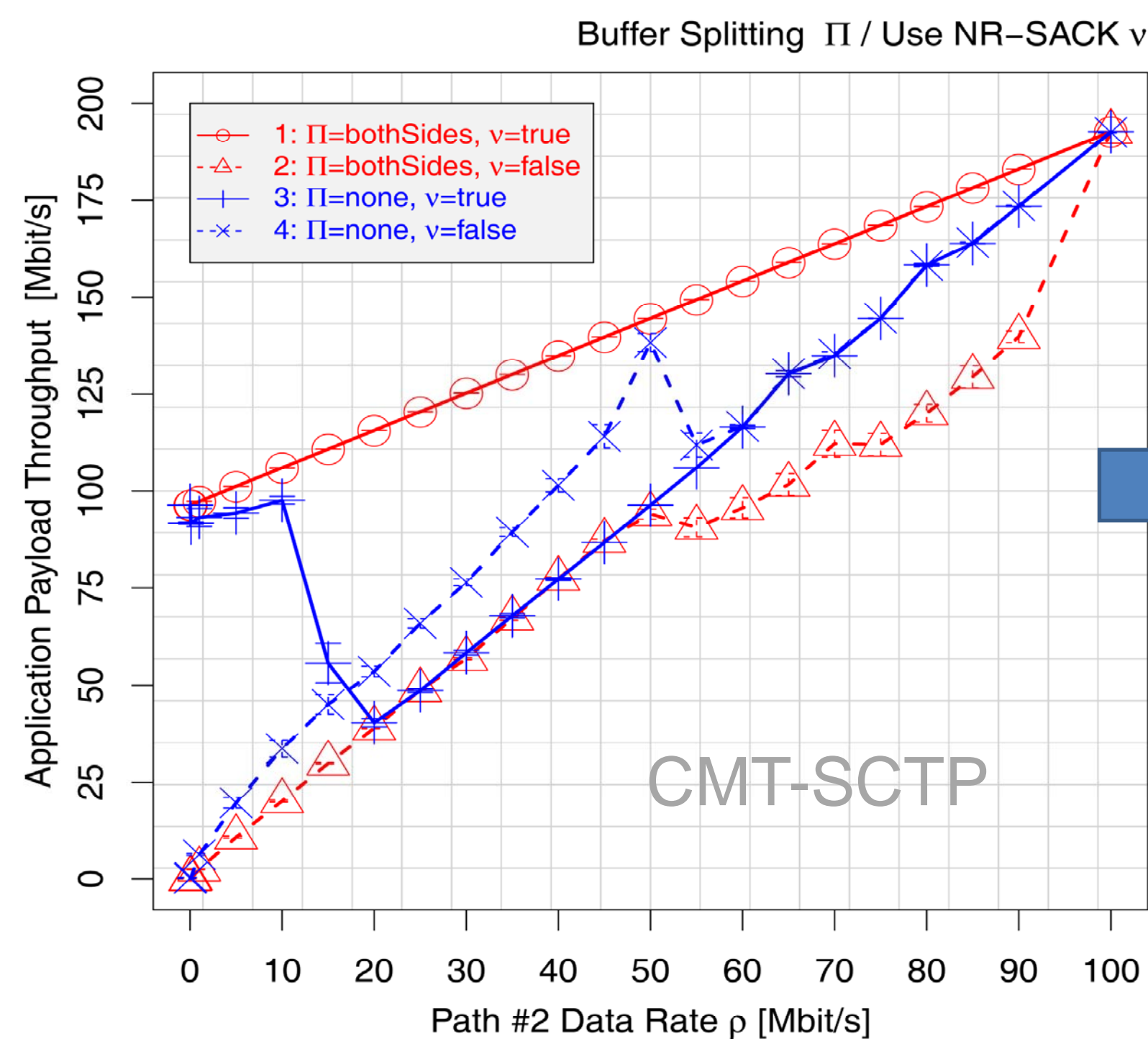SACK · CumAck · Gap Reports
After SACK Processing:

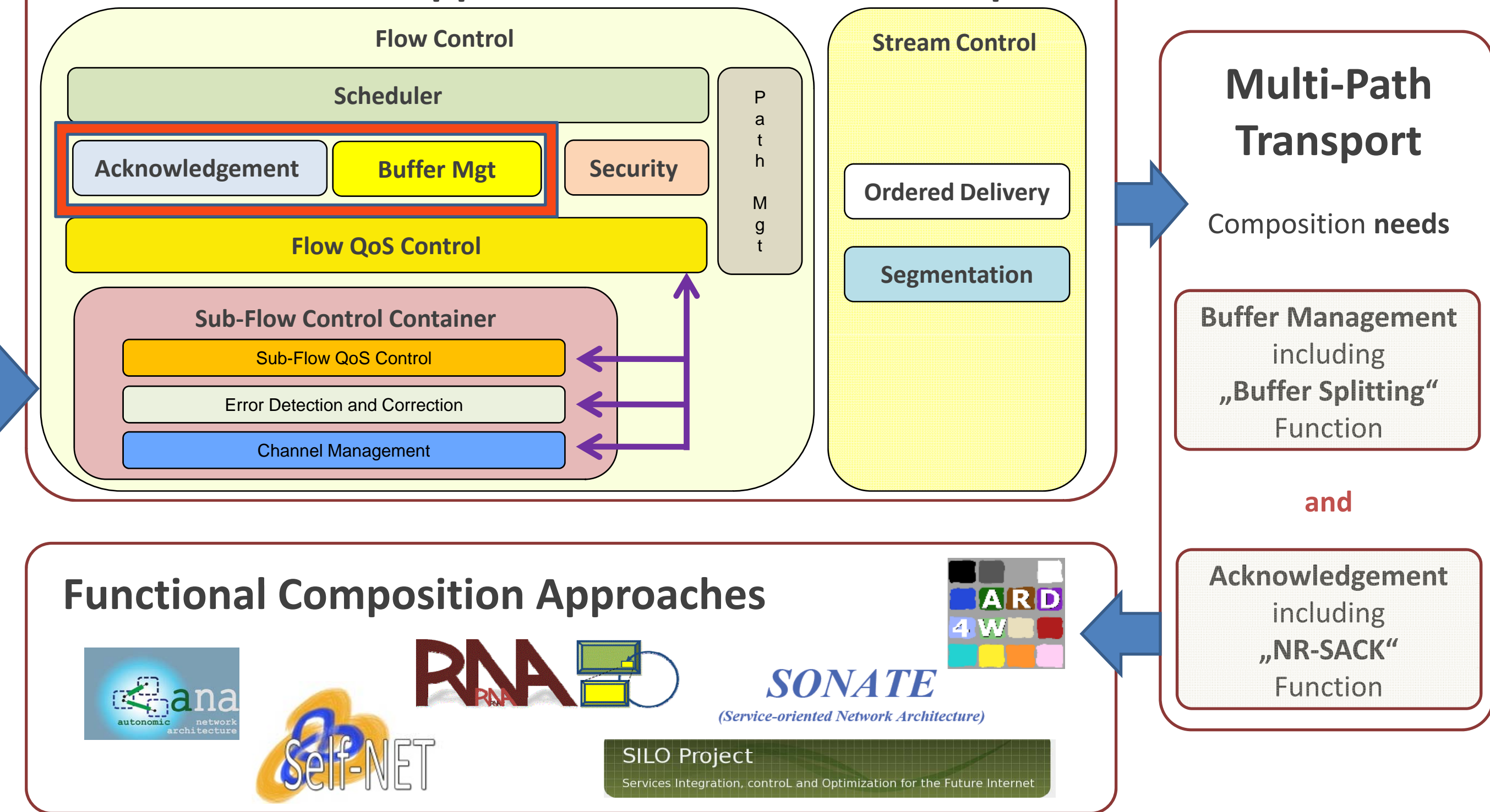# Results of Evaluation applied to new Architectures

Combination of Buffer Splitting and NR-SACK needed!

Simulation Setup

- OMNeT++/INET and SimProcTC
- Own CMT-SCTP and CMT/RP-SCTP models
- Path #1: 100 Mbit/s, 1ms delay, loss-free
- Path #2: variable QoS parameters
- Saturated sender, MTU-sized packets by utilizing

NetPerfMeter Network Performance Tool

Buffer Splitting Π / Use NR–SACK ν

1: Π=bothSides, ν=true
2: Π=bothSides, ν=false
3: Π=none, ν=true
4: Π=none, ν=false

Application Payload Throughput [Mbit/s]
Path #2 Data Rate ρ [Mbit/s]

CMT-SCTP

Functional Block Approach for Multi-Path Transport

Flow Control
Scheduler
Acknowledgement · Buffer Mgt · Security
Flow QoS Control
Sub-Flow Control Container
Sub-Flow QoS Control
Error Detection and Correction
Channel Management

Stream Control
Ordered Delivery
Segmentation

Path Mgt

Functional Composition Approaches

ana · RNA · SelfNET · SONATE (Service-oriented Network Architecture) · SILO Project (Services Integration, control, and Optimization for the Future Internet) · 4WARD

Multi-Path Transport

Composition **needs**

Buffer Management including „Buffer Splitting" Function

and

Acknowledgement including „NR-SACK" Function

G-Lab DEEP

- Load Sharing Experiments
- Cross Layer VoIP Security
- http://www.g-lab-deep.de/

Work in G-Lab

- Common Multi-Path Experiments
- Measurement and Monitoring
- Testbed Setups

SIG Multi-Path

UNIVERSITÄT DUISBURG ESSEN

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