DIMECC

ONE SEA
Autonomous maritime ecosystem

Sea4Value

Future Fairway Navigation

Benchmarking of Emulated Wireless Edge Cloud Connectivity for Maritime Environments

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Participation

WP3 Technical transformation

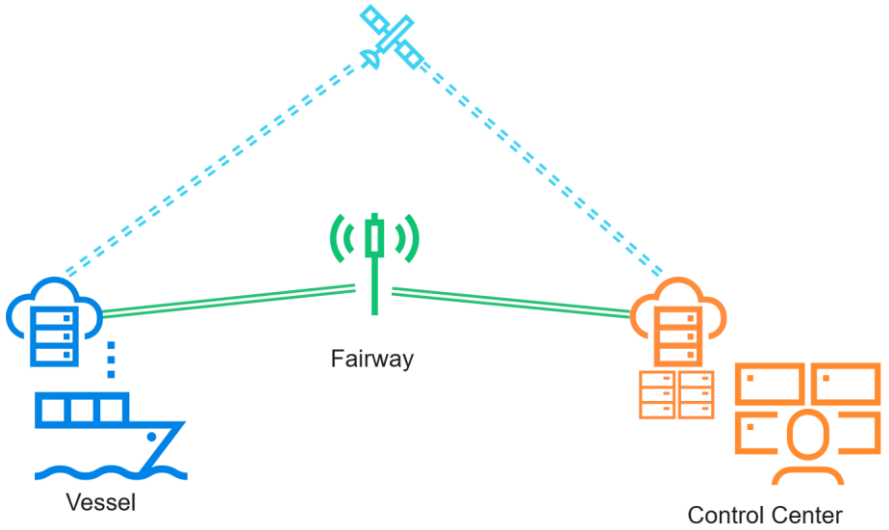
- WP3.3 Fog and Edge Computing

Experiments

I External traffic shapers

II Internal traffic shapers

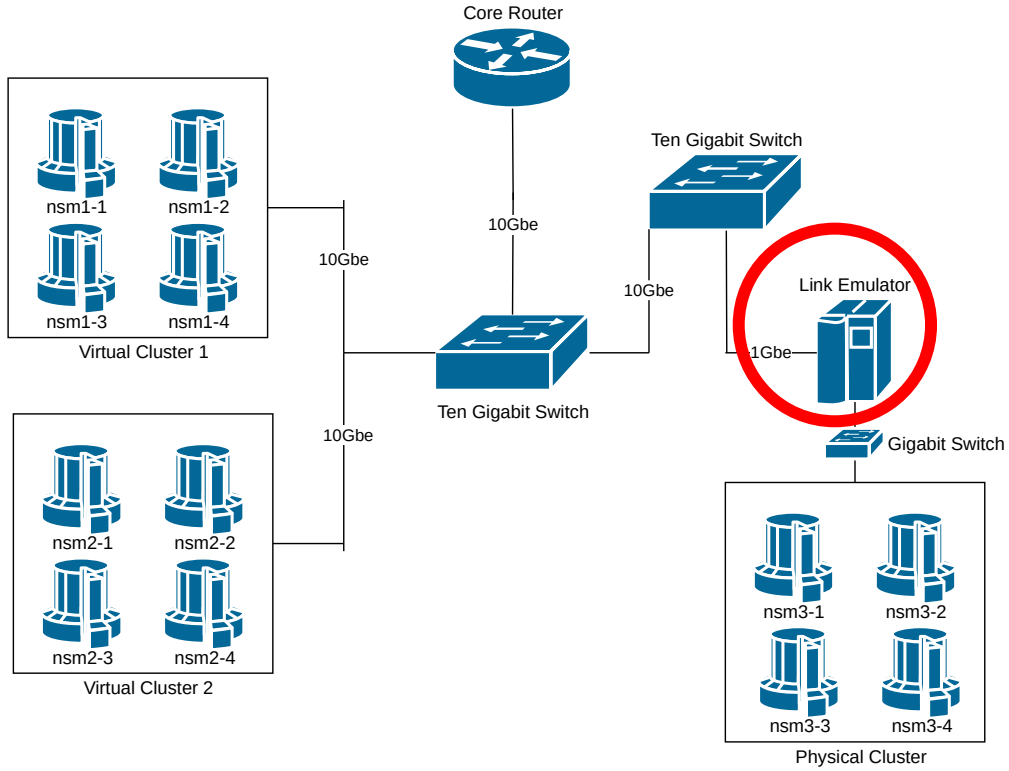
Introduction



- Multi-cloud edge computing in ships and control centers
  - Edge clouds operated as a single unit..
  - ..but remain autonomous upon network partitioning (Federation)
- Ships can utilize both cellular and satellite connectivity
  - Different latency and bandwidth characteristics
  - Moving ships + wireless network = varying traffic loss
- Wireless connectivity + multi-cloud edge computing = ???
  - Emulated testbed for wireless multi-cloud networking (Kubernetes)
  - Wireless network emulated using a traffic shaper in a wired network

Testbed

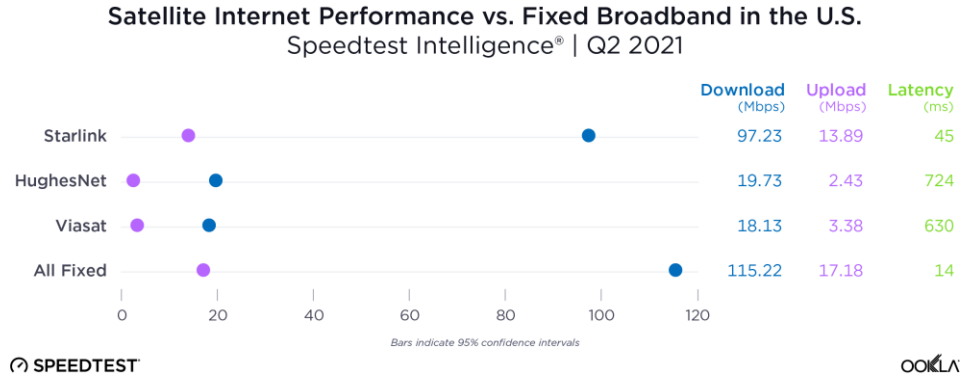
- Federated Kubernetes
  - Bare metal + virtual machines
- Network Service Mesh
- External link emulator
  - Mimics 5G and satellite network
  - FreeBSD + dummynet
  - Controls packet loss rate, bandwidth and latency
- Traffic generator: iperf3 (TCP)



Traffic Generation and Emulation Parameters

Service	Data Rate
GMDSS	10 Kbps
Radar/AIS	100 Kbps
Infotainment	1500 Kbps
LIDAR	2000 Kbps

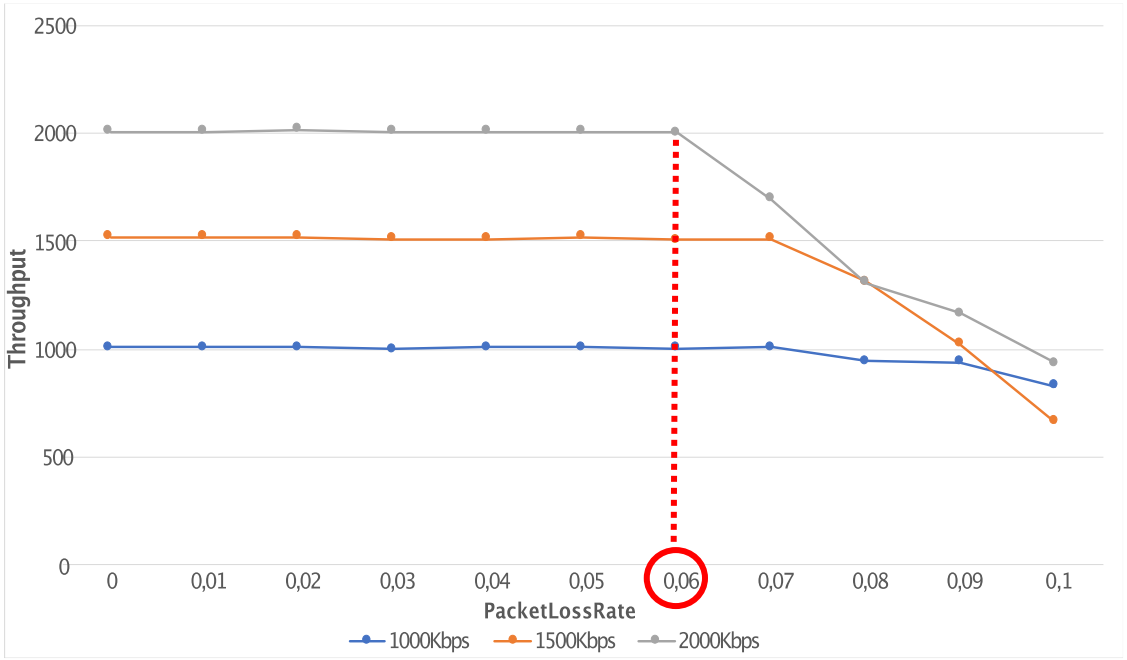
Table III
BANDWIDTH USED BY DATA SERVICE



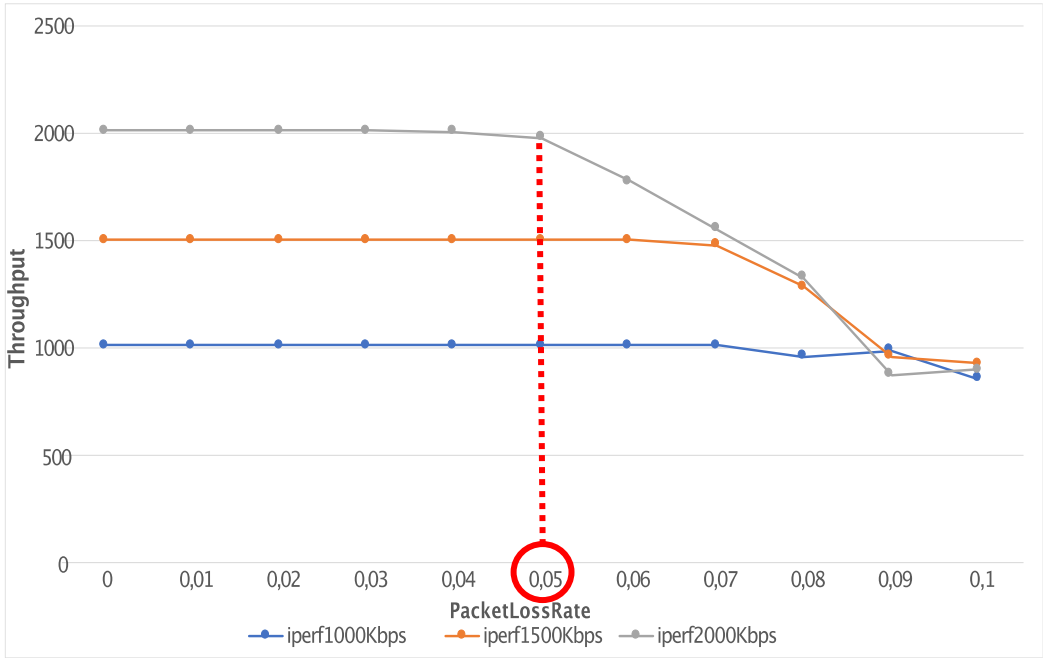
Service	Uplink (Mbps)	Downlink (Mbps)	Latency up/down (ms)
Satellite #1	5	30	125/125
Satellite #2	3	18	315/315
5G #1	88	535	6/6
5G #2	29	592	13/13

Table IV
DUMMYNET LINK PARAMETERS

Benchmark results 1/4

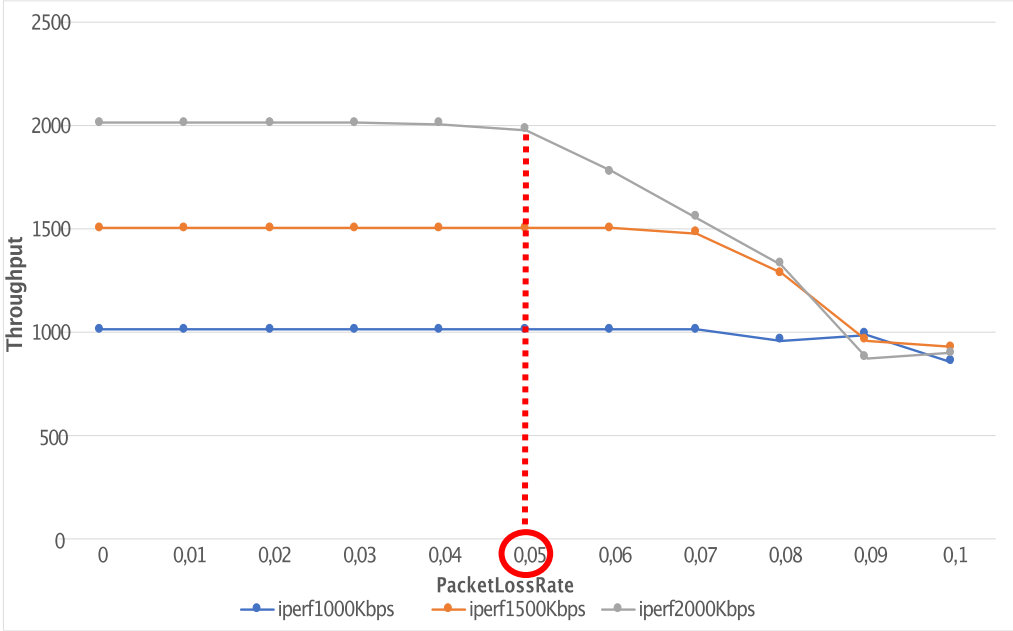


Host networking with 5G #1 (non-Kubernetes)

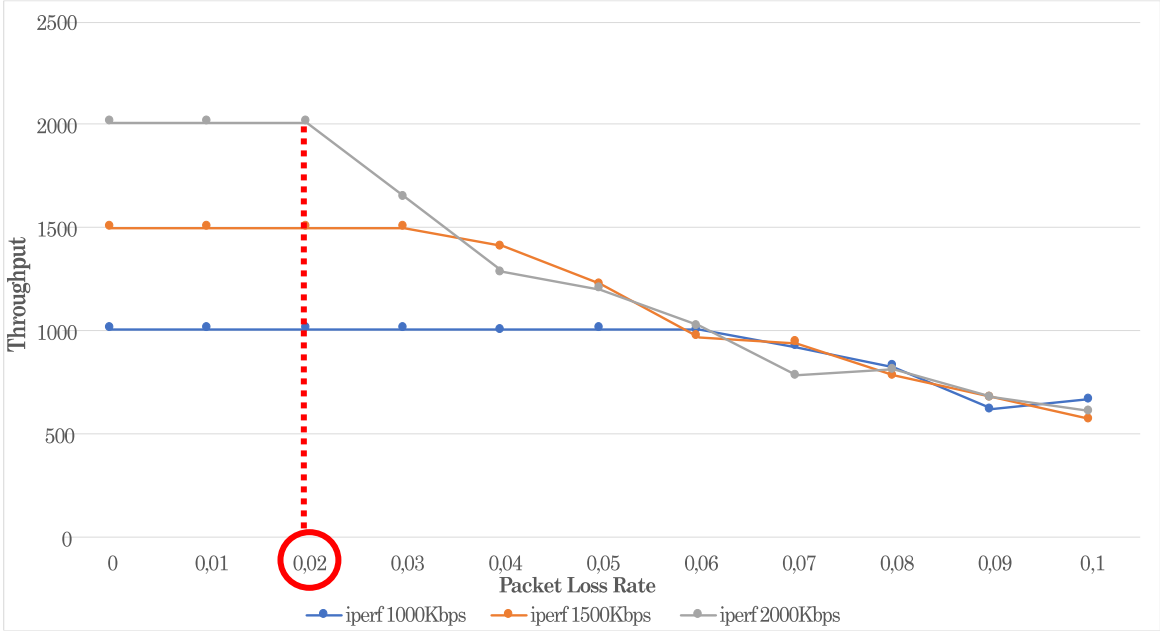


Kubernetes with 5G #1

Benchmark results 2 / 4

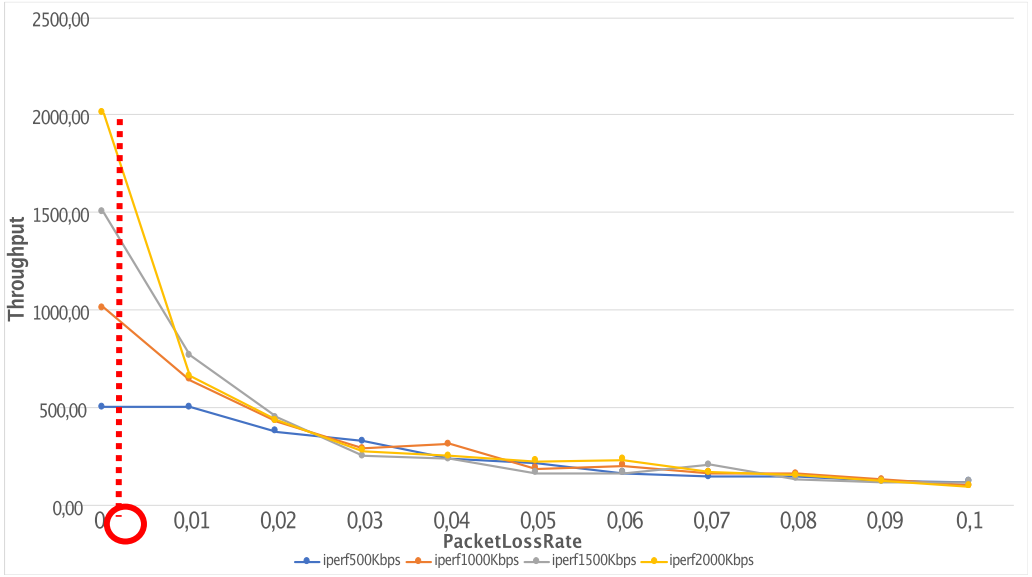


Kubernetes with 5G #1 (6 ms latency)

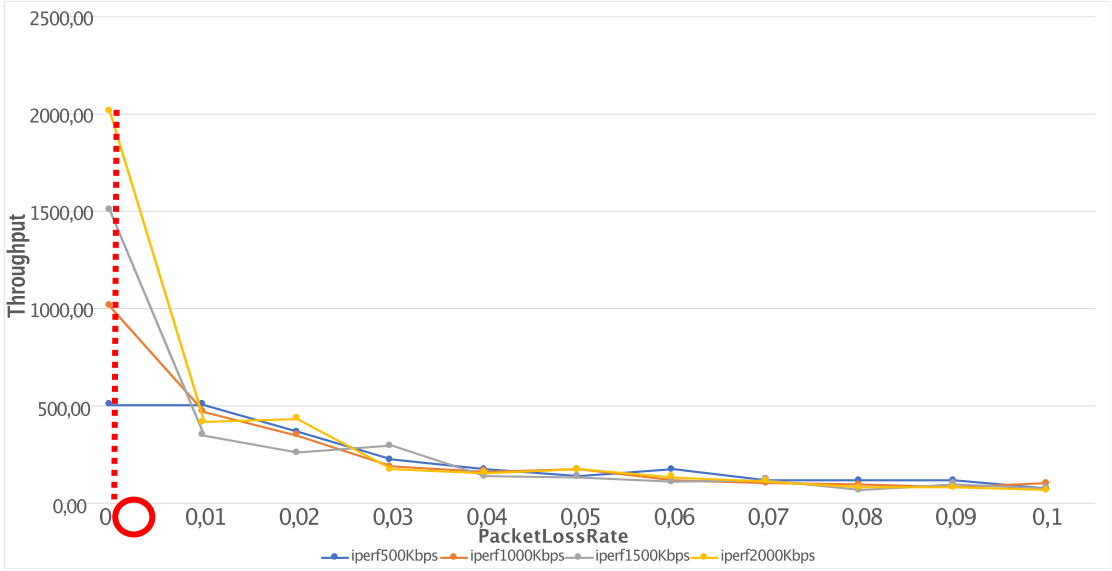


Kubernetes with 5G #2 (13 ms latency)

Benchmark results 3 / 4

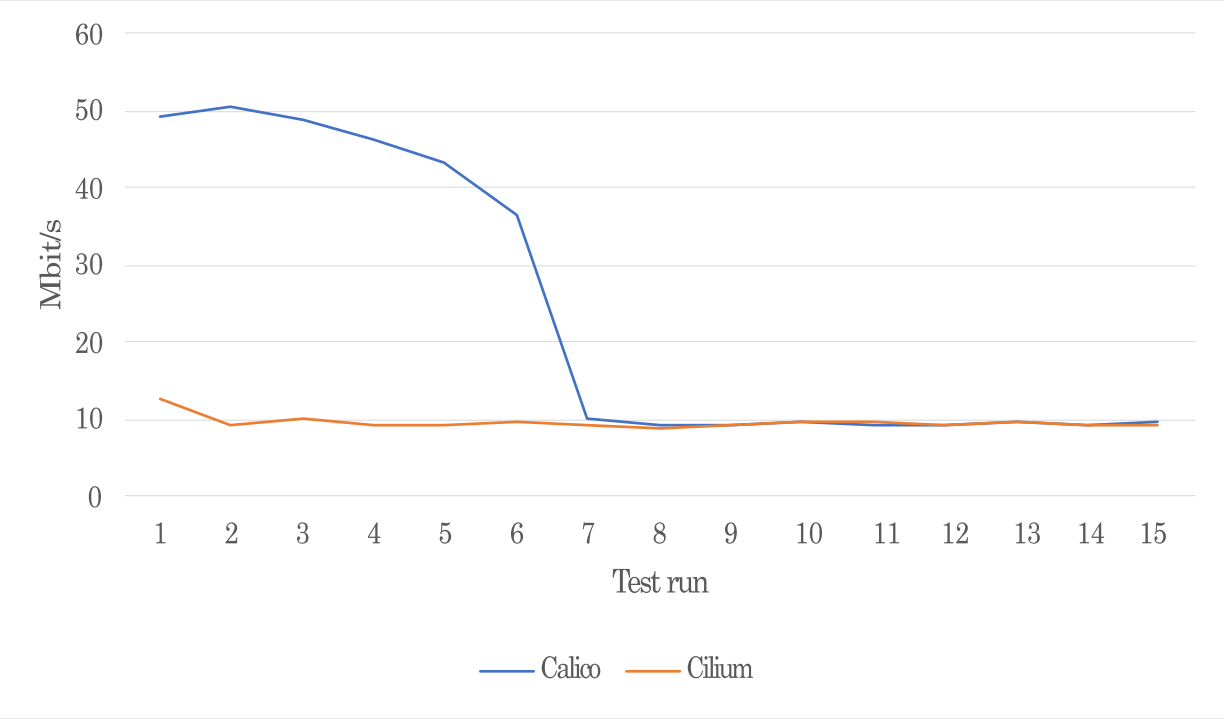


Kubernetes with Satellite #1 (latency 125 ms)



Kubernetes with Satellite #2 (latency 315 ms)

Benchmark results 4 / 4



- Benchmarked also Kubernetes internal traffic shapers
  - Calico and Cilium
  - Single cloud because only Cilium supports multi-cloud
- Bandwidth capped to 10 Mbit/s
  - Cilium works ok but caps only outbound direction
  - Calico lets some traffic through initially and did not work reliably with smaller b/w cap

Conclusions & Future Work

- Emulated multi-cloud networking in a wireless environment
  - Benchmarked cloud internal and external traffic shapers in Kubernetes
  - Paper accepted to IEEE World Forum for Internet of Things
- Main findings
  - Kubernetes networking does not add much overhead
  - Increase in latency impacts bandwidth negatively with TCP
  - Kubernetes internal traffic shapers can further be improved
- Future work
  - Benchmarking of CPU usage
  - Parallel data connections & automated traffic prioritization and shaping

Thank you!

Any questions?