Full-stack SDN: The Next Big Challenge?

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Disclaimer

Call for Papers - SOSR 2020

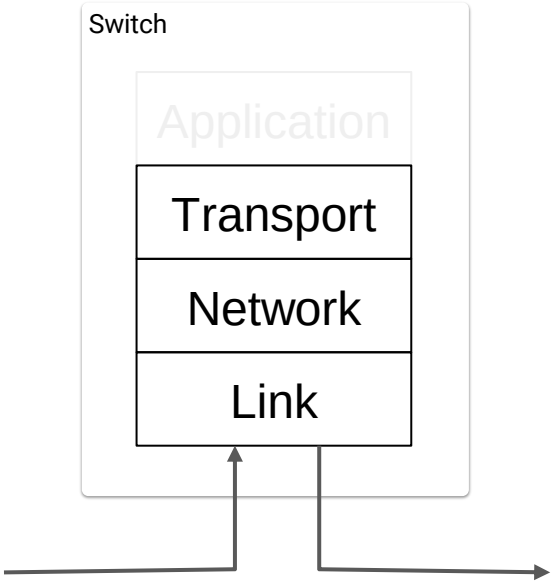
New This Year: Experience and Challenge Submissions

In addition to traditional research papers, this year the SOSR Organizing Committee is excited to announce the solicitation of Experience and Challenge papers. Given SDN has been successfully deployed in a variety of production environments, "Experience" papers detailing, evaluating, or providing a retrospective of the practical impacts of SDN deployments will be of great use to the scientific community. And while SDN technologies are currently deployed in production environments, the promise of software-driven networking remains large. As such, "Challenge" papers outlining the next steps, challenges, or radical ideas for software-driven networking and systems will also be requested. Both long and short Challenge and Experience papers are invited.

- This is a "Challenge" paper
- Don't expect answers, only some (hopefully) interesting questions

TLDR;

Ethernet bridges handle packets at L2, IP routers at L3, and middleboxes add L4 processing capability



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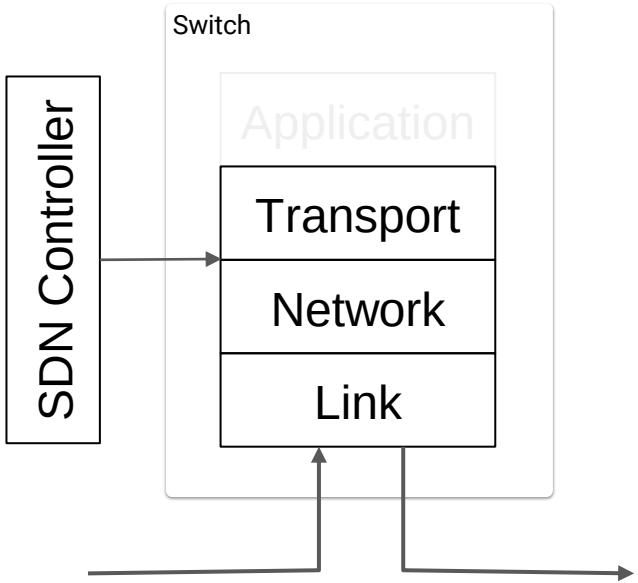

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Software Defined Networking (SDN): impose L2-L4 network policies centrally

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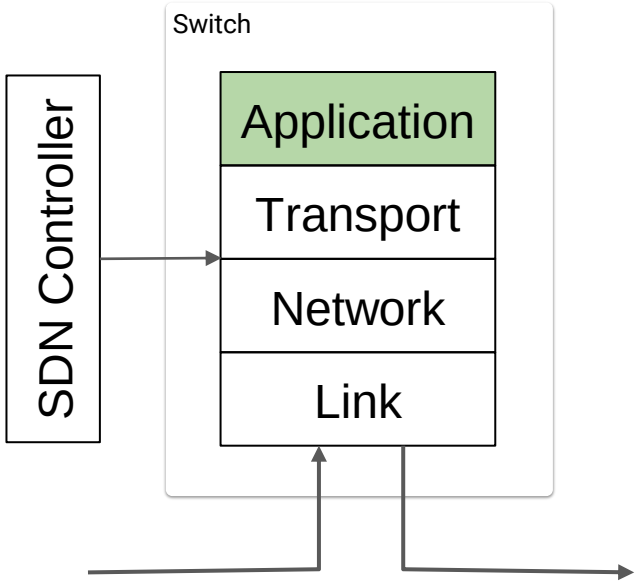


Ethernet bridges handle packets at L2, IP routers at L3, and middleboxes add L4 processing capability

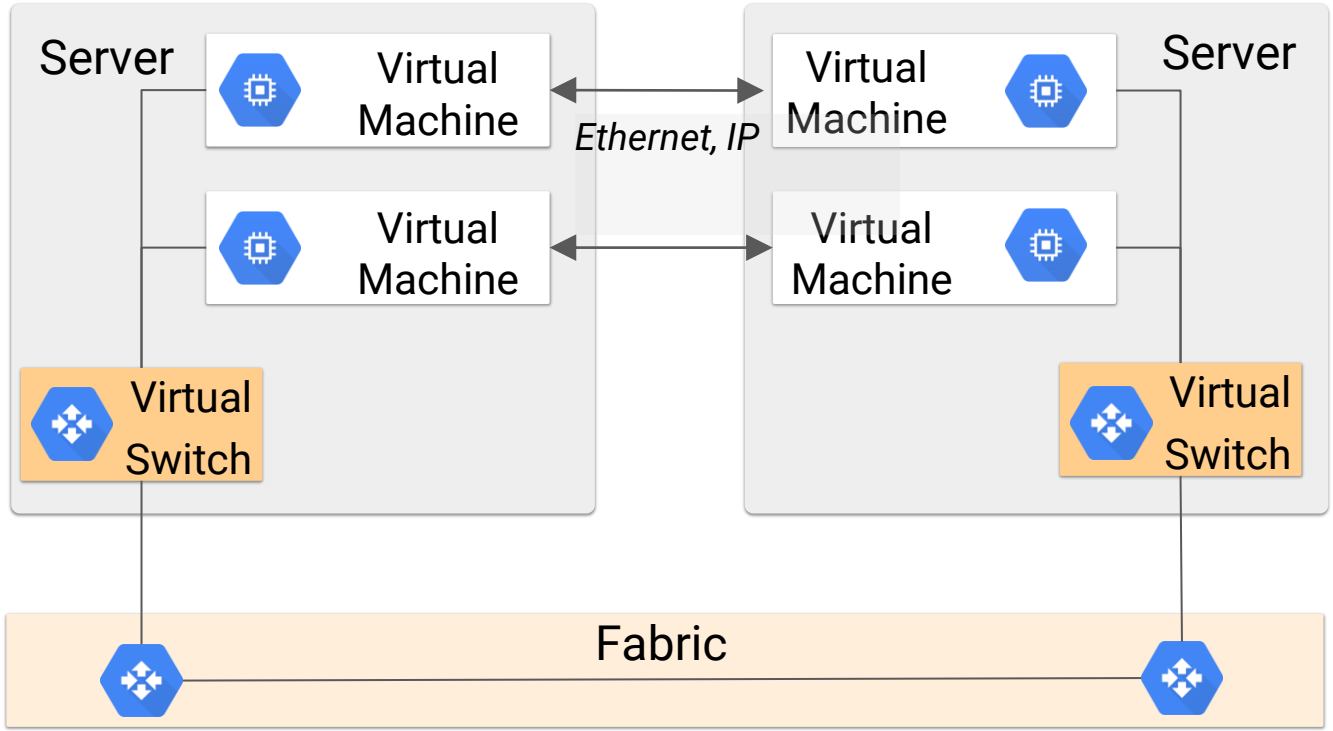
Software Defined Networking (SDN): impose L2-L4 network policies centrally

We argue it is time to extend SDN up into the Application layer (L7)

TLDR;

Questions? :D

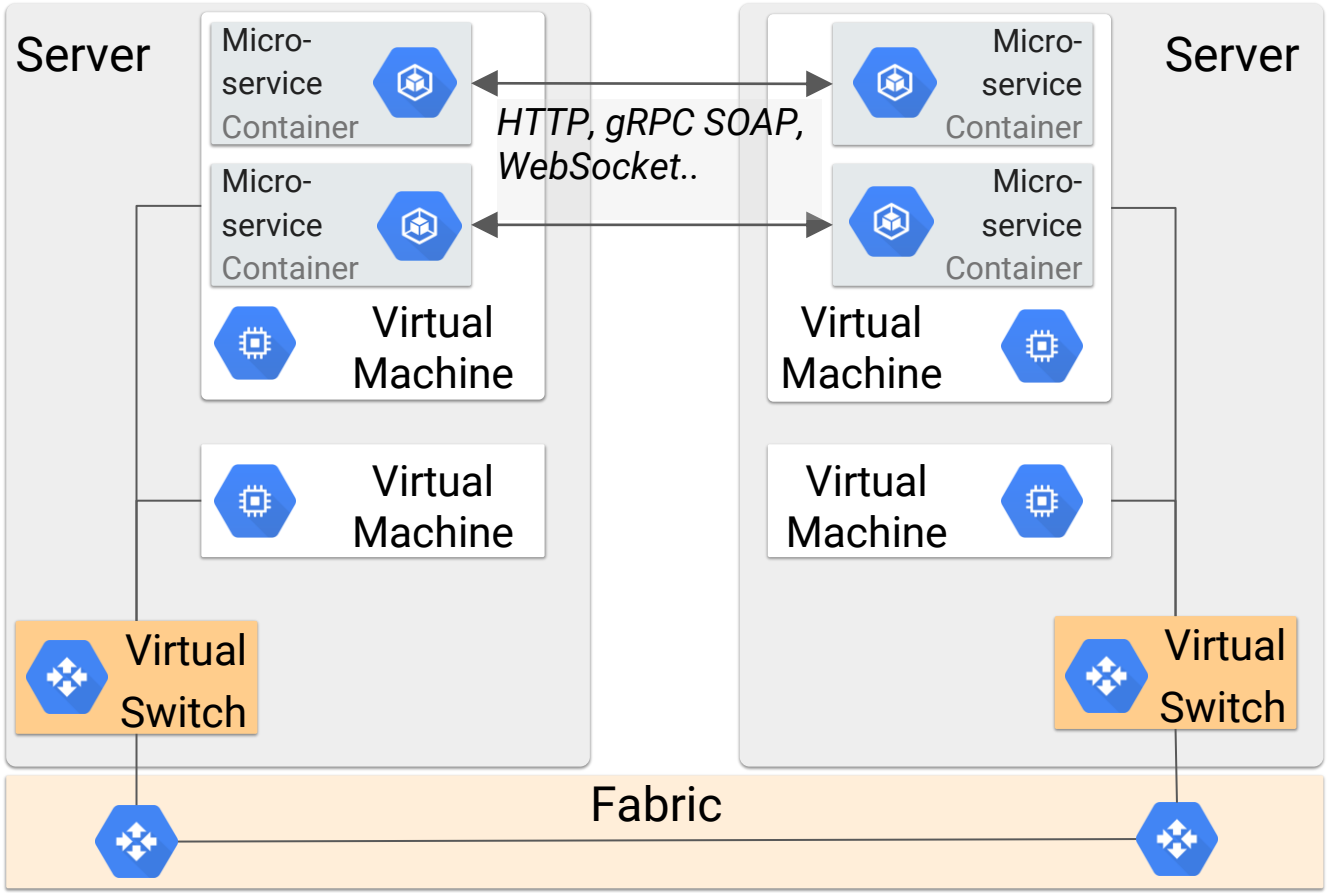
Cloud 1.0: Monolithic apps deployed into VMs



Full app instances deployed into VMs

Exchange traffic over L2 and L3 protocols

Cloud 2.0: Microservices



Fine-grained decomposition of business logic into loosely coupled microservices

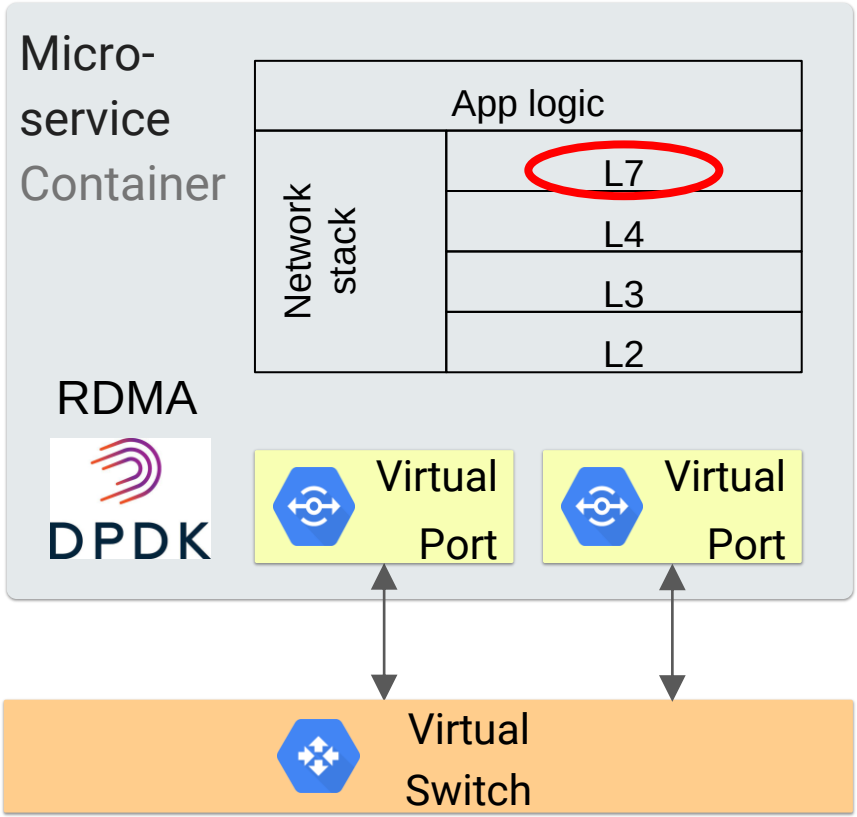
Lightweight isolation in Linux containers

Expose/consume services over application-layer (L7) protocols

Takeaway 1

With the transition to the microservice architecture, **the main network communication pattern becomes application-layer (L7) protocols**

Looking glass on microservices

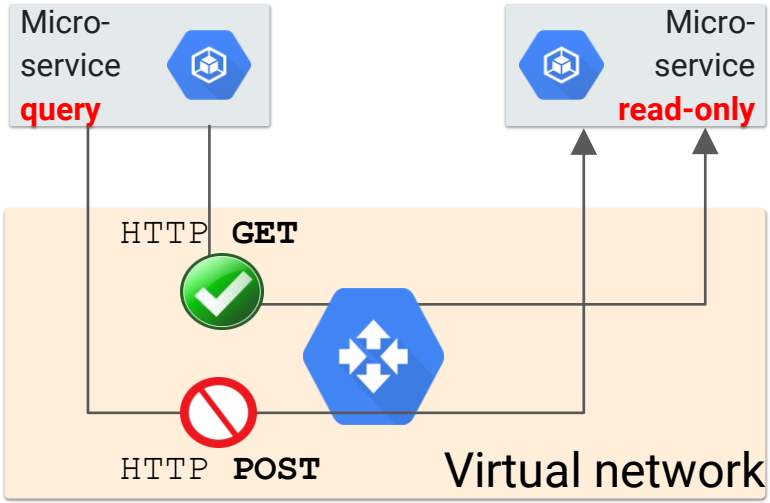


Microservice communication relies on critical L7 network functions that are hardcoded into applications

Examples: Load-balancing, L7 ACLs, circuit breaking, L7 health-checking, encryption, policing, observability, authentication and authorization

Cannot impose L7 network policies centrally

Example 1: Filter HTTP REST API calls



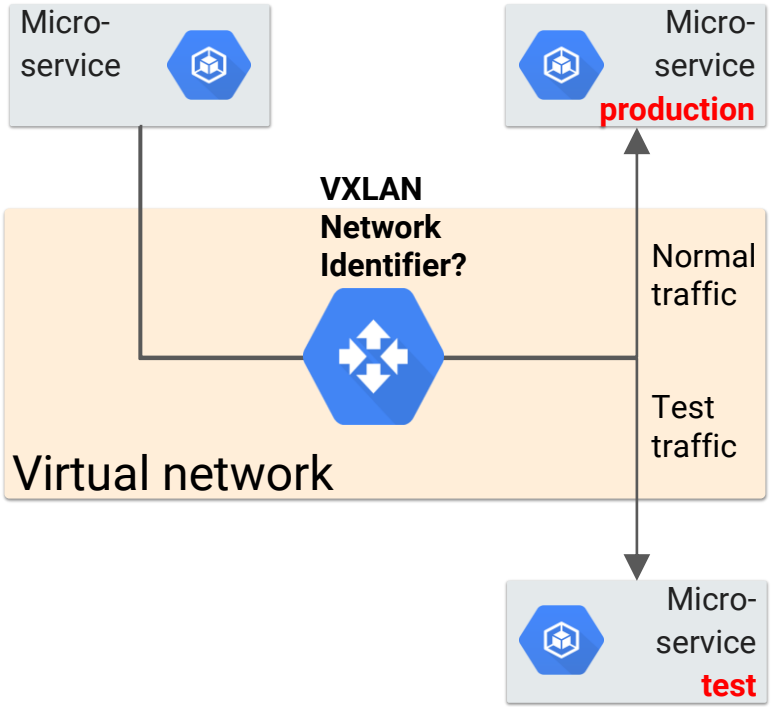
Microservices typically expose/consume services over RESTful HTTP APIs

These look the same for a conventional L2-L4 SDN switch (TCP, port=80/443)

The network **SHOULD** be able to filter connections based on HTTP header fields

The control plane **SHOULD** be able to set L7-ACLs in switches

Example 2: Differentiate/route based on VXLAN ID



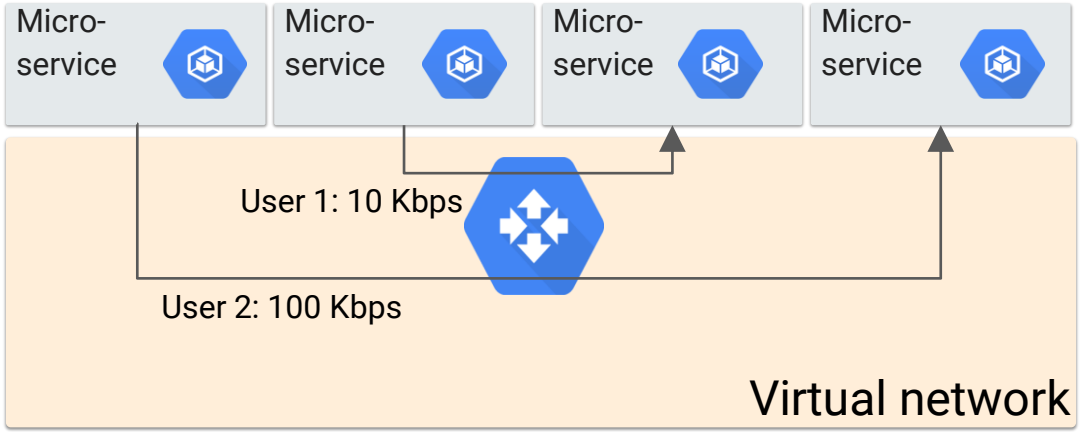
If a new service version is deployed alongside production code..

VXLAN tunnels look the same for an L2-L4 SDN switch (UDP port is 4789)

The network **SHOULD** be able to handle traffic at the granularity of VXLAN Network Identifier!

The control plane **SHOULD** be able to install VXLAN routing rules in the dataplane

Example 3: Police RTP streams by user ID



RTP streams look the same for an L2-L4 SDN switch

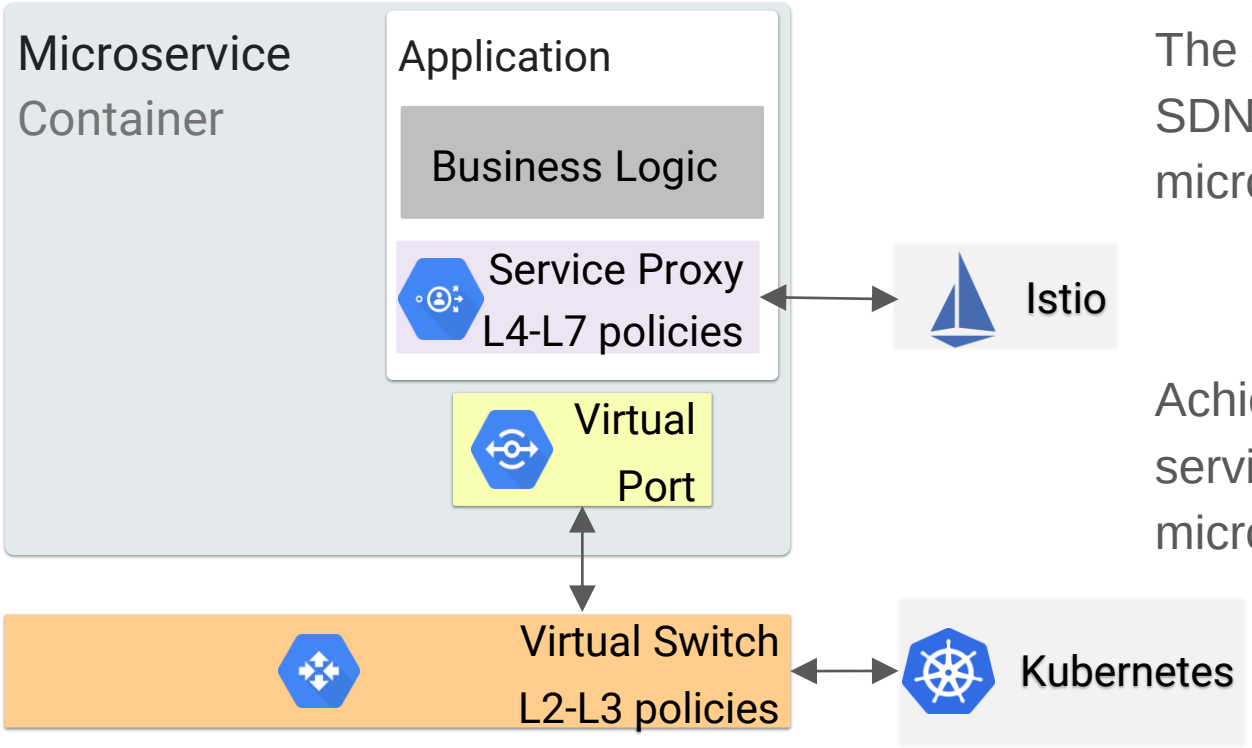
The network **SHOULD** be able to rate-limit RTP streams based on user ID (SSRC)

The control plane **SHOULD** be able to set/query counters at the granularity of individual RTP streams

Takeaway 2

Application-layer network functions SHOULD be moved out from applications into the dataplane to allow the enforcement of L7 network policies centrally

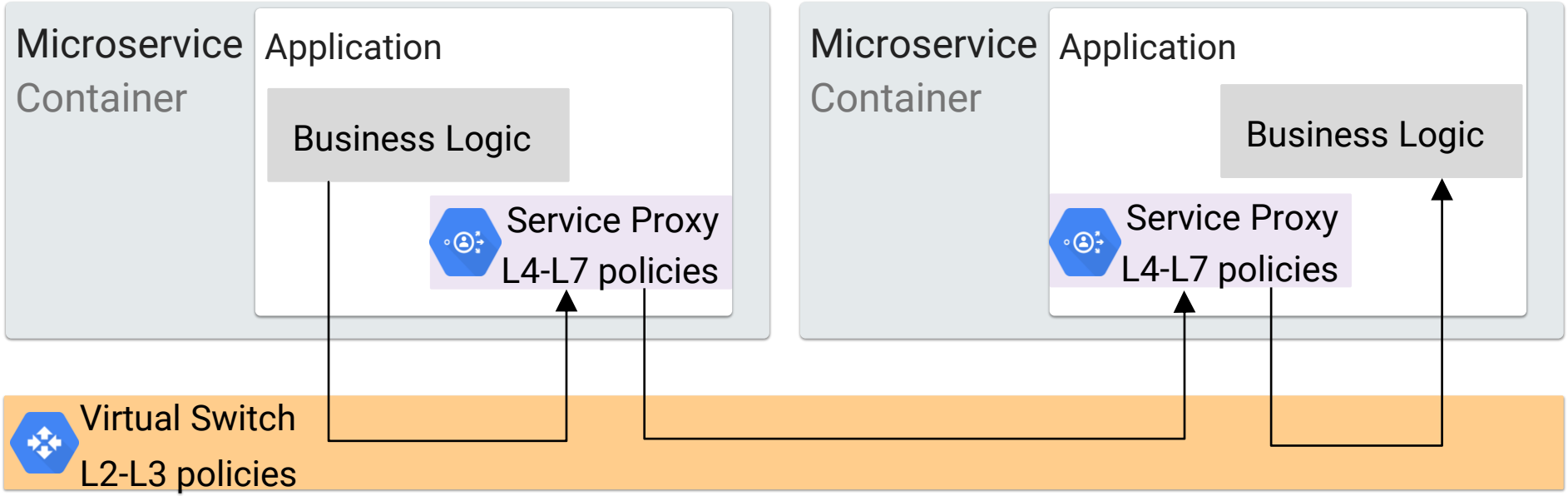
State-of-the-art: The service mesh



The **service mesh** is an L7-SDN to manage HTTP-based microservice communication

Achieved by injecting an HTTP service proxy to each microservice

State-of-the-art: The sidecar proxy model



The proxy runs side-by-side with the app and intercepts all ingress/egress traffic

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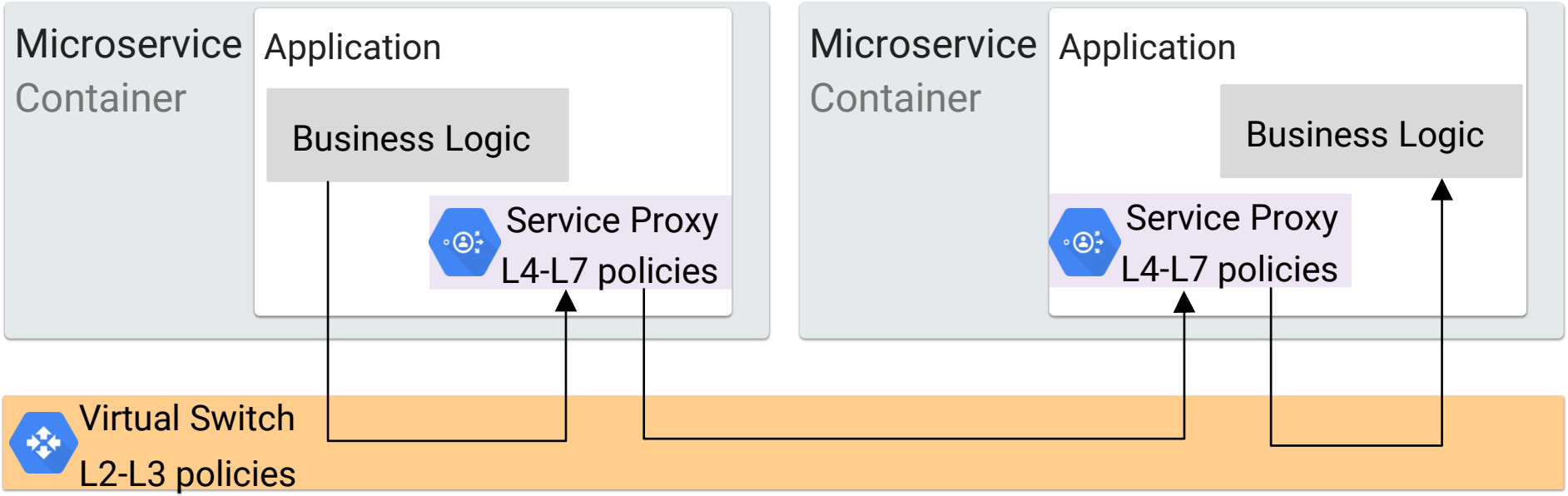
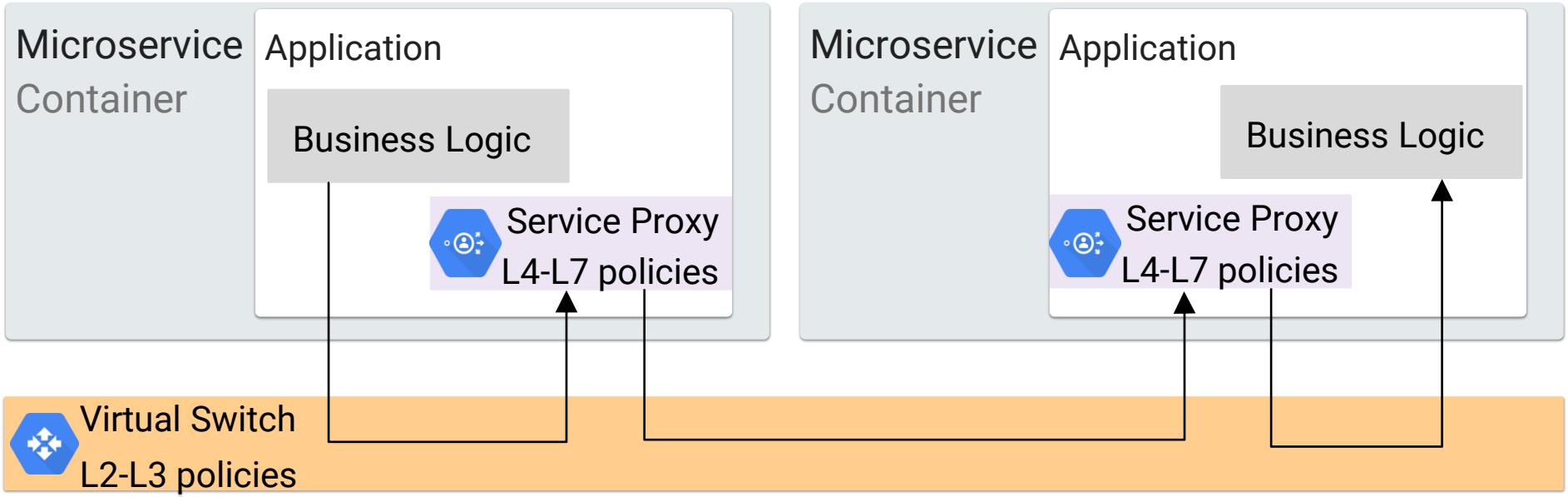


Even a local packet exchange requires stitching 3 connections one after the other

This is 6 kernel-space--user-space context switches (remote calls are even worse)

State-of-the-art: The sidecar proxy model

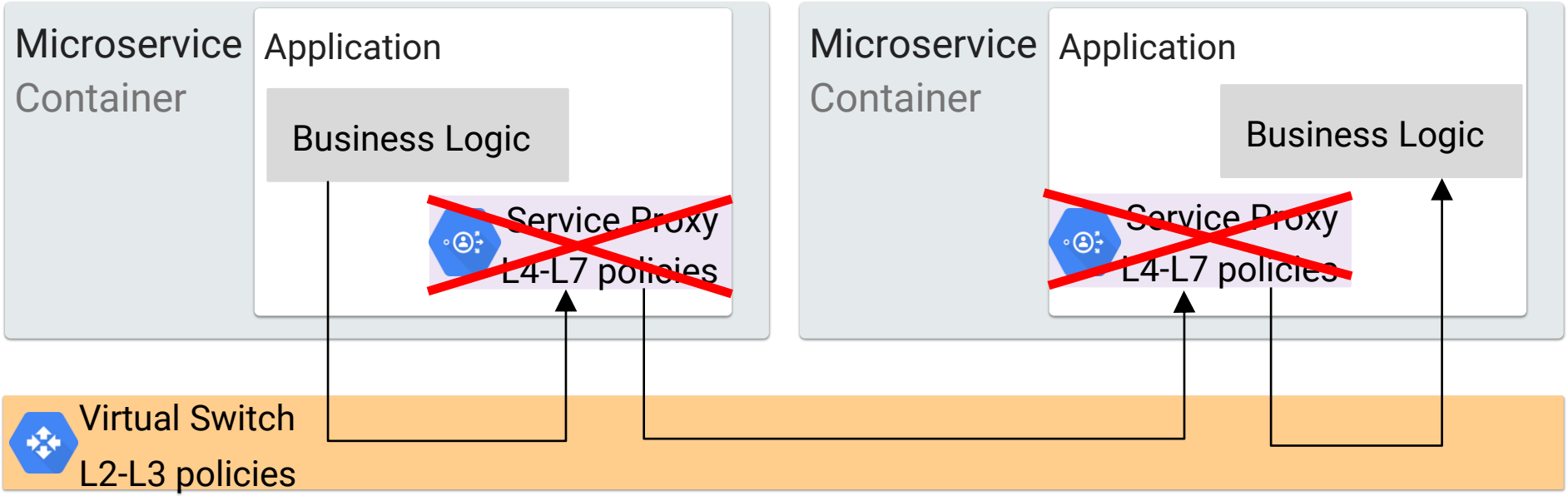


Check the paper for some numbers on how this architecture might affect network function performance!

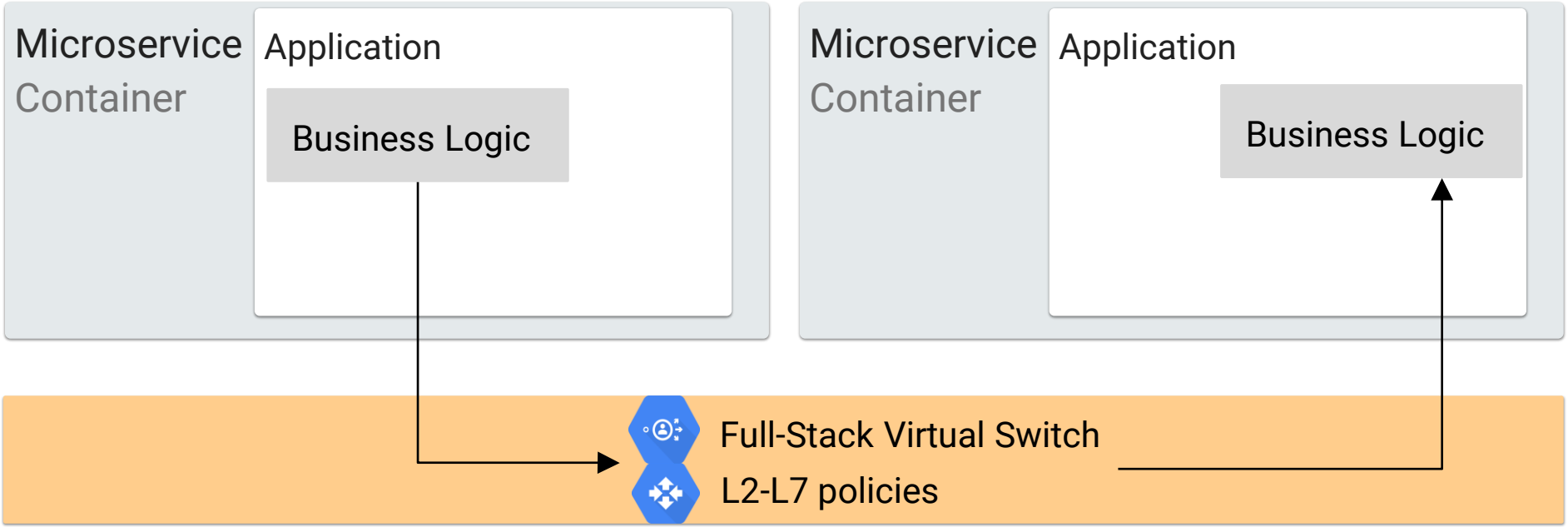
Takeaway 3

The state-of-the-art L7 SDN is restricted to HTTP and runs on top of the inefficient sidecar-proxy model

The challenge: Full-stack SDN



The challenge: Full-stack SDN



A local packet exchange would require now only 1 simple connection

This is only 2 kernel-space--user-space context switches!!!!

Full-stack SDN: How?

Process traffic at any layer in the protocol stack (UDP, TCP, RTP, WebSocket, Ethernet, IP, etc..)

Key components:

- Full-stack SDN switch
- Full-stack SDN control plane

See a couple of initial ideas in the paper

Conclusions

Takeaway 1
With the transition to the microservice architecture, **the main network communication pattern becomes application-layer (L7) protocols**

Takeaway 2
Application-layer network functions SHOULD be moved out from applications into the dataplane to allow the enforcement of L7 network policies centrally

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Challenge: Full-stack SDN

Thanks!