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NaaS

Network-as-a-Service in the Cloud

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joint work with
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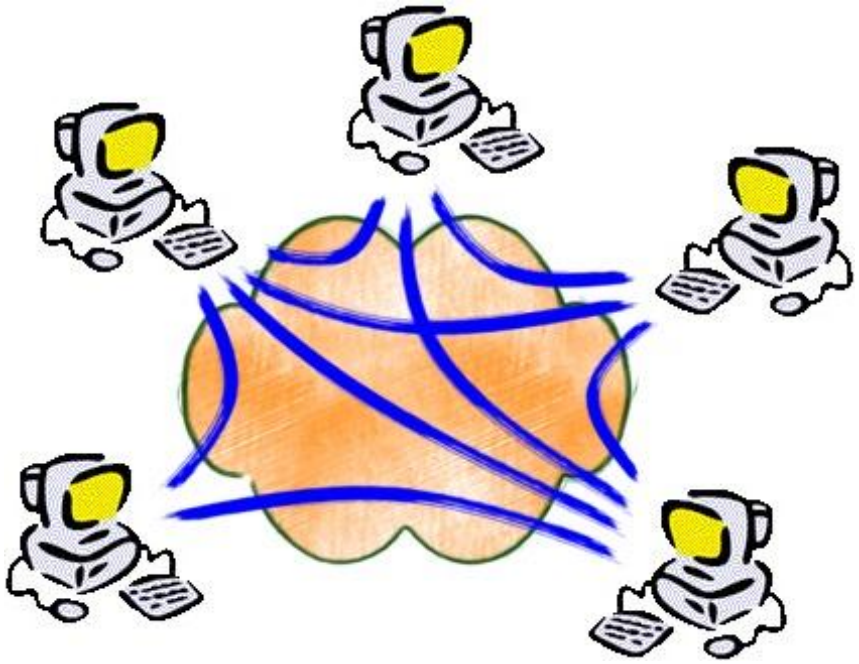
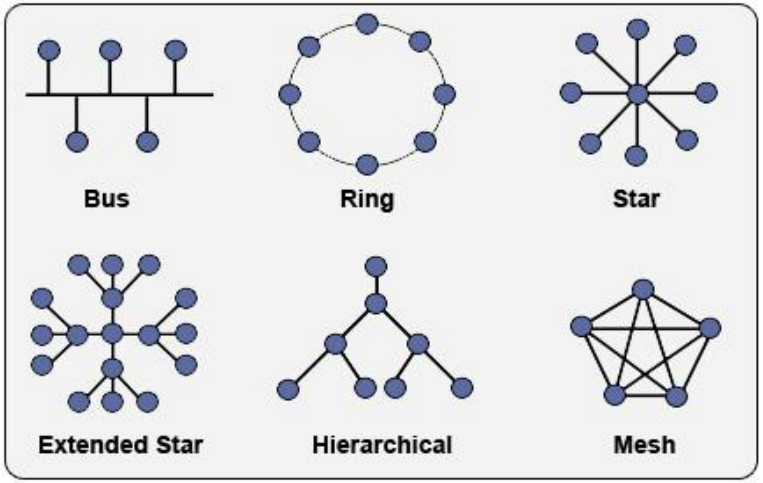
Motivation

Mismatch between app. abstractions & network

- How the programmers see the network

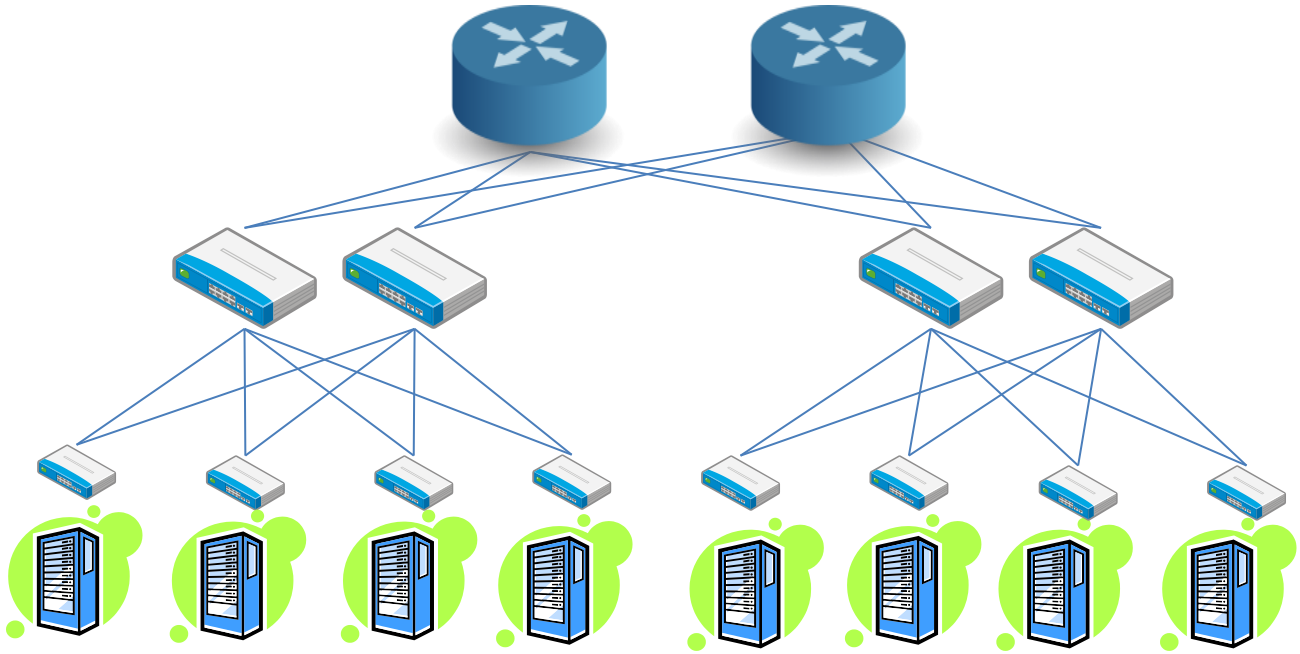




Motivation

Mismatch between app. abstractions & network

- How the network really looks like



Motivation

Mismatch between app. abstractions & network

- What programmers really see of the network

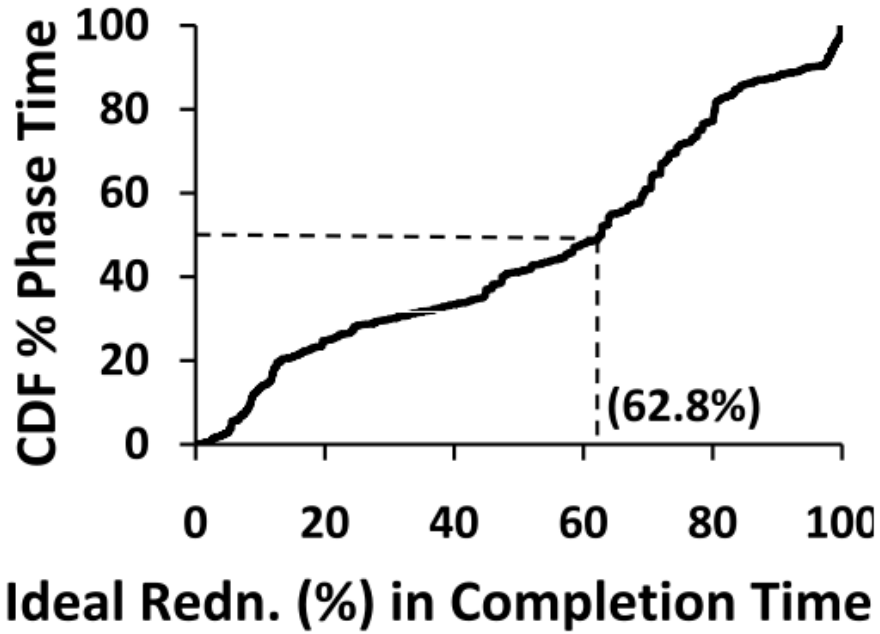
```
int send(int sockfd, const void  *msg,
         int len, int flags);

int recv(int sockfd, void *buf,
         int len, int flags);
```

✘ No control over network resources

✘ Hard to map distributed apps onto the physical topology

Example #1: MapReduce

- Many cloud data centers have high degree of oversubscription (e.g., 1:20[IMC'10])
  - Intra-rack bandwidth >> inter-rack bandwidth
- Location of map and reduce tasks is critical



70% of cross track traffic is reduce traffic

50% reduce phases takes 62% longer than ideal placement

Source: Ananthanarayanan et al. OSDI'10

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  - Intra-rack bandwidth >> inter-rack bandwidth
- Location of map and reduce tasks is critical
- Current approach
  - *Reverse-engineer the network*
    Combination of low-level tools (ping, traceroute, …) and complex clustering algorithms
- Issues
  - Low-level process
  - Time consuming
  - Potentially inaccurate

Example #1: MapReduce

- Many cloud data centers have high degree of oversubscription (e.g., 1:20[IMC'10])
  - Intra-rack bandwidth >> inter-rack bandwidth

Wish list #1: Network Visibility

Tenants are provided with an (abstract) view of their allocated VMs

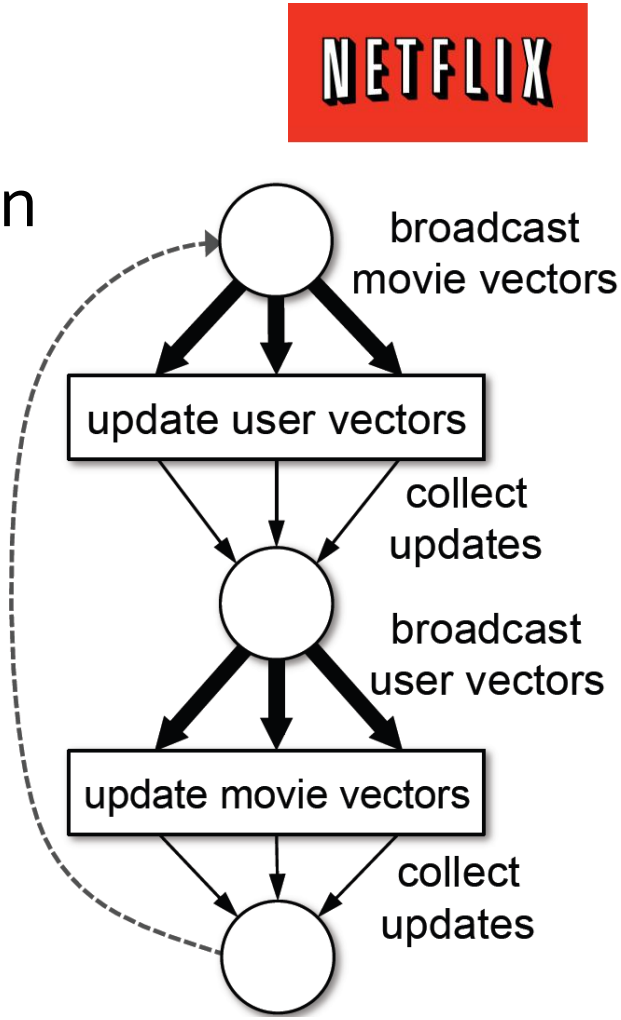
No need for reverse-engineering, easier deployment

clustering algorithms

- Issues
  - Low-level process
  - Time consuming
  - Potentially inaccurate

Example #2: Iterative Jobs

- Iterative jobs often adopt an one-to-many communication pattern
  - e.g., Netflix Collaborative Filtering
- Current approach
  - Point-to-point
  - Application-level multicast tree
  - BitTorrent-like solutions



Source: Chowdhury et al. SIGCOMM'11

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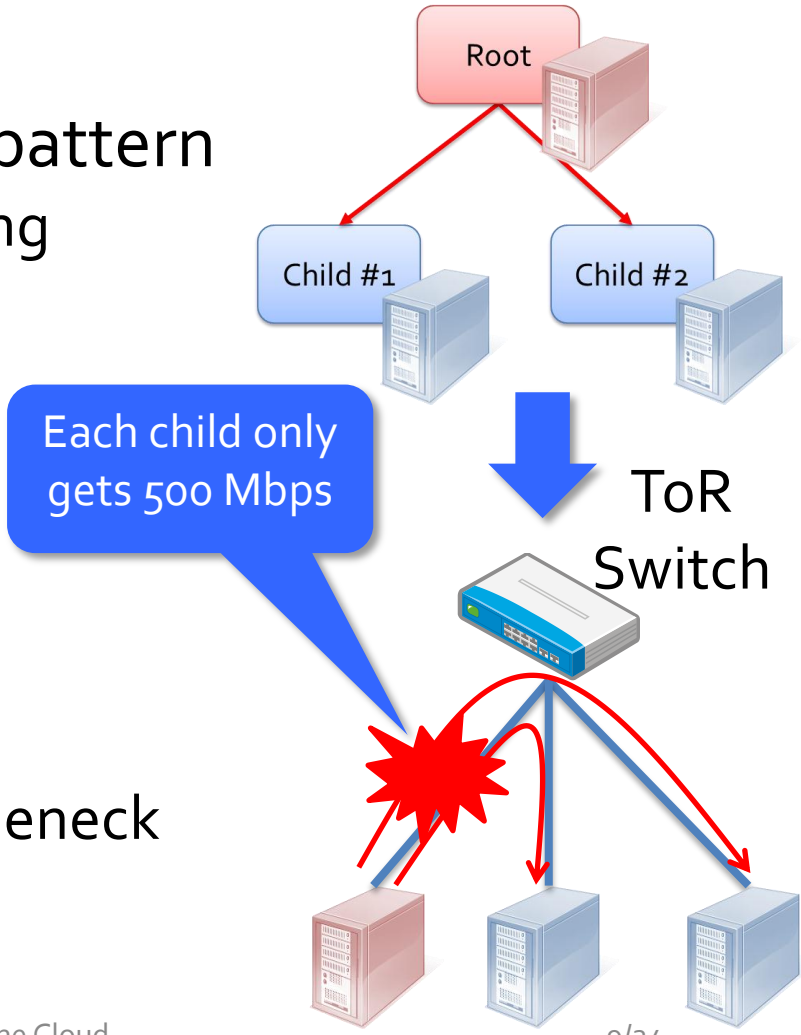
- Issues
  - The server 1Gbps link is the bottleneck
  - Even perfect network visibility would not help



Example #2: Iterative Jobs

- Iterative jobs often adopt an

Wish list #2: Custom Forwarding

Tenants can implement custom routing protocols
E.g., anycast, multicast, content-based routing,
key-based routing, multi-path routing, …

- Issues
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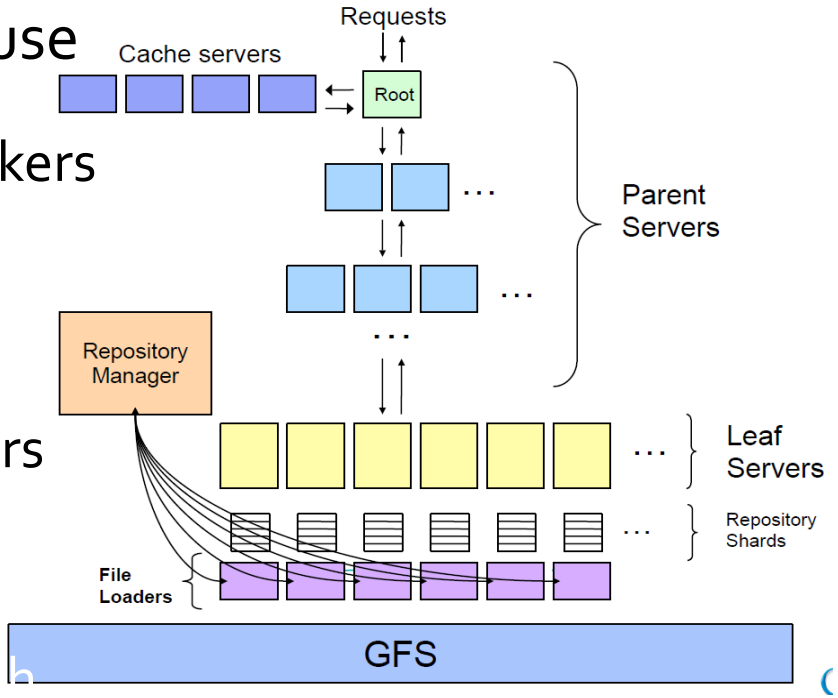
  - Even perfect network visibility would not help

Example #3: Interactive Queries

- Many large-scale web services use a partition-aggregate pattern
  - Queries are sent to multiple workers and responses are combined
- Current approach
  - Responses from workers are aggregated at intermediate layers
  - E.g., Google Search



Source: Jeff Dean. WSDM'09

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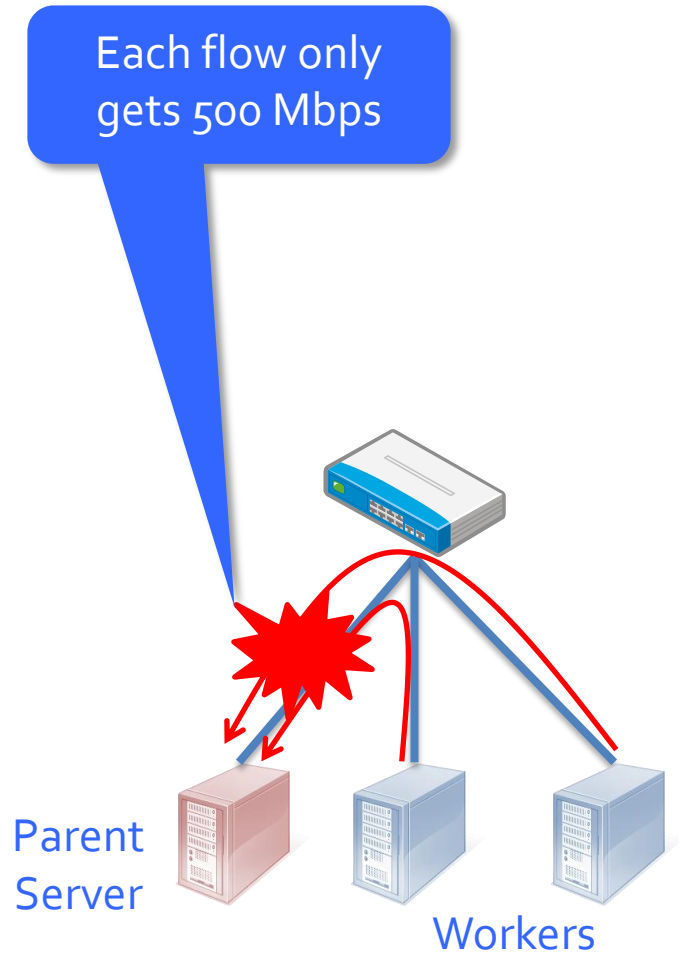

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- Many large-scale web services use a partition-aggregate pattern

Wish list #3: In-network Processing

Tenants can perform arbitrary packet processing on path
E.g., in-network aggregation [Camdoop@NSDI'12], opportunistic caching, semantic de-duplication

  - Requires high network bandwidth
  - Aggregator servers become the bottlenecks
  - Custom forwarding would not help

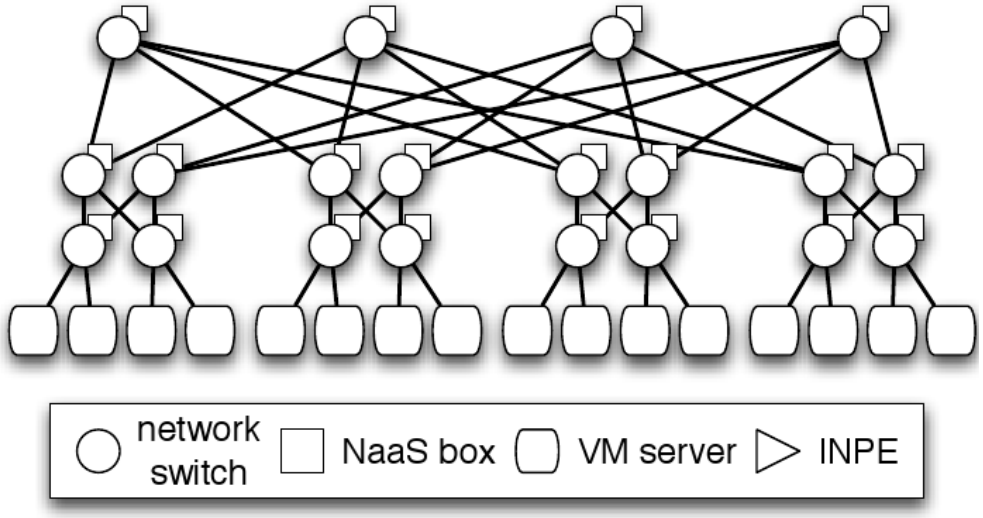
Introducing NaaS

- Goal
  - *Mechanisms and abstractions to enable cloud tenants to efficiently, easily, and safely process packets within the network*
- This entails visibility over network resources, custom forwarding and processing of packets
- Providers would benefit too
  - Today they also need to reverse-engineer applications
  - NaaS would allow more fine-grained traffic engineering
- This is complementary to…
  - SDN / OpenFlow / …
  - Focus on application-specific rather than application-agnostic services
- …but some techniques can be re-used

Why Now?

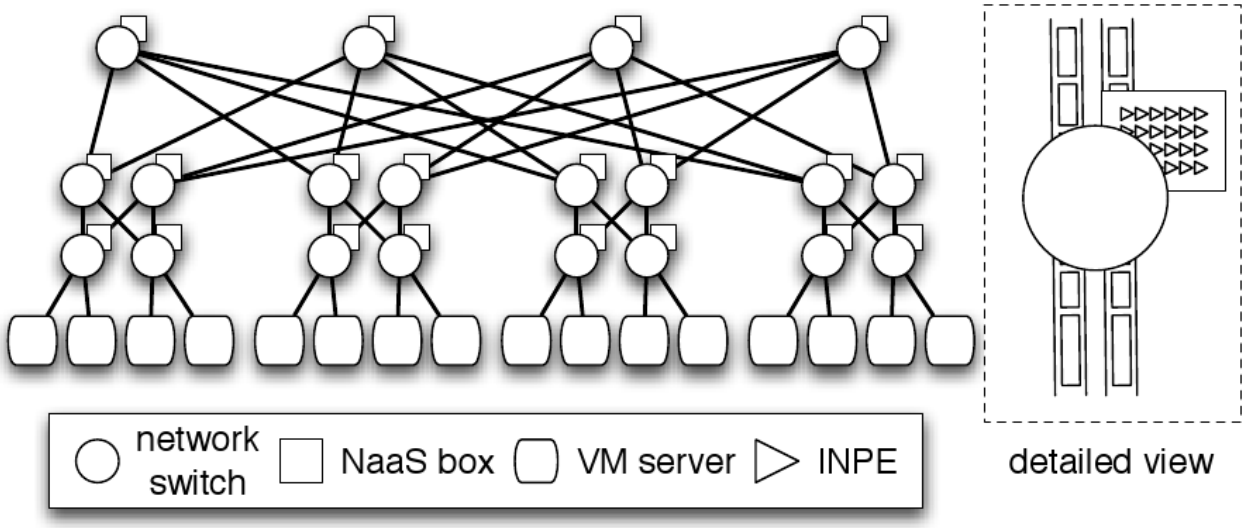
- *DCs are not mini-Internets*
  - Single owner / administration domain
  - We know (and define) the topology
  - Low hardware and software (network protocols) diversity
  - Trusted components (e.g., hypervisors)
- Several proposals for software-based routers
  - RouteBricks , ServerSwitch, PacketShader , SideCar, NetMap, …
- Typically, these are used to replace traditional (*application-agnostic*) network services (e.g., IPv4 forwarding, DPI)
- *Why don't use them also to implement application-specific services?*
  - E.g., aggregate packets in a distributed query or content-based routing

NaaS Architecture



- Switches are augmented with processing capabilities
  - Software routers a la Routebricks or hybrid solutions like ServerSwitch
- (Oversubscribed) Fat-tree-like topology
  - Lower in-bound switch throughput
  - E.g., for a 27K-server, max throughput is 48 Gbps

NaaS Architecture

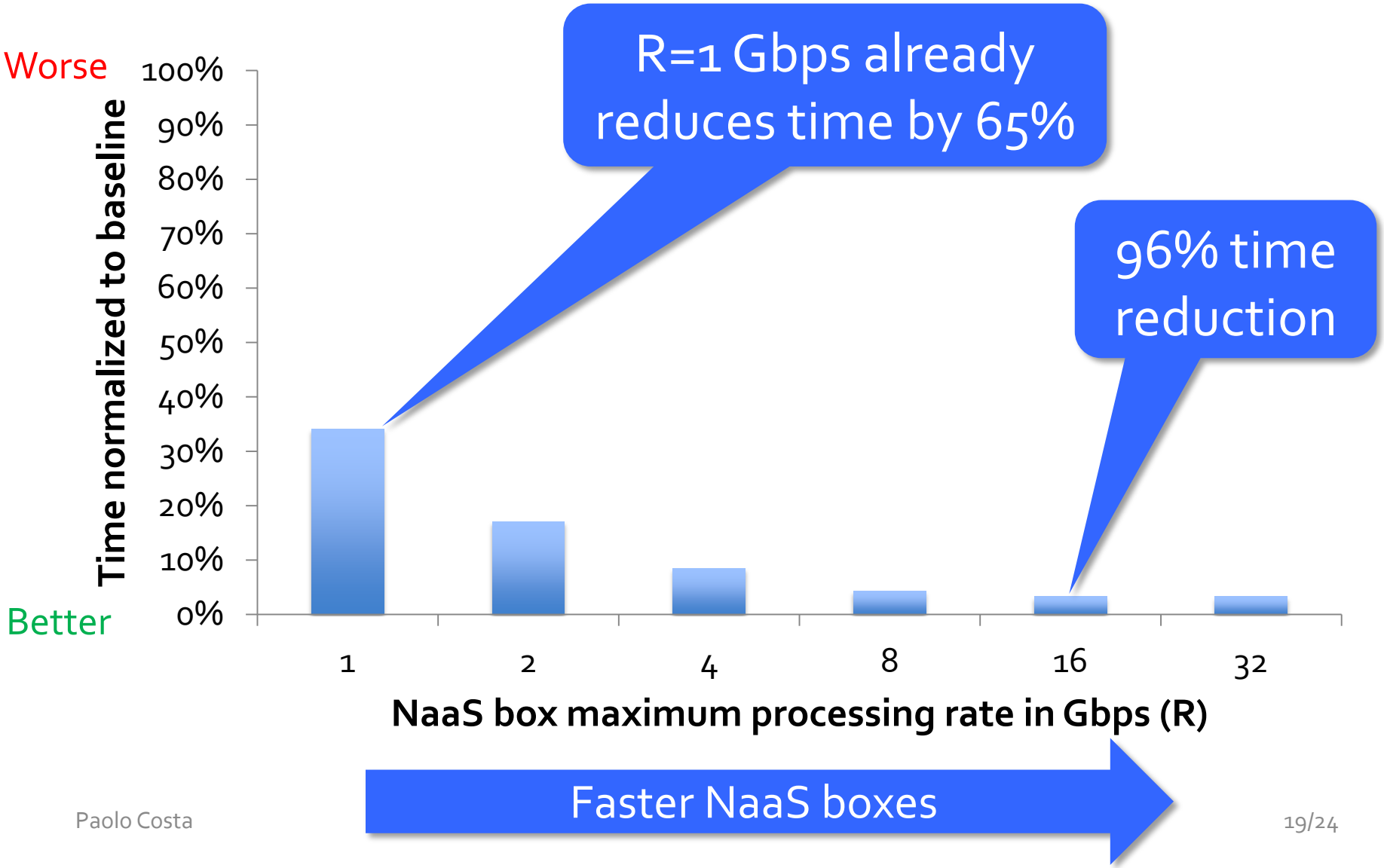


- Switches are augmented with processing capabilities (NaaS box)
  - Software routers a la Routebricks or hybrid solutions like ServerSwitch
- (Oversubscribed) Fat-tree-like topology
  - Lower in-bound switch throughput
  - E.g., for a 27K-server, max throughput is 48 Gbps
- Tenants deploy their processing elements (INPE) on each NaaS box
  - Fast-path for non-NaaS traffic

(Preliminary) Evaluation

- Questions:
  - *What are the benefits for NaaS users?*
  - *What is the impact for non-NaaS users?*
  - *What is the processing rate required?*
- Setup
  - Flow-level simulator
  - 8,192-server fat-tree topology (32-Gbps switches)
  - 80% traditional TCP flows, 20 % combination of multicast, aggregation, caching

Total flow completion time



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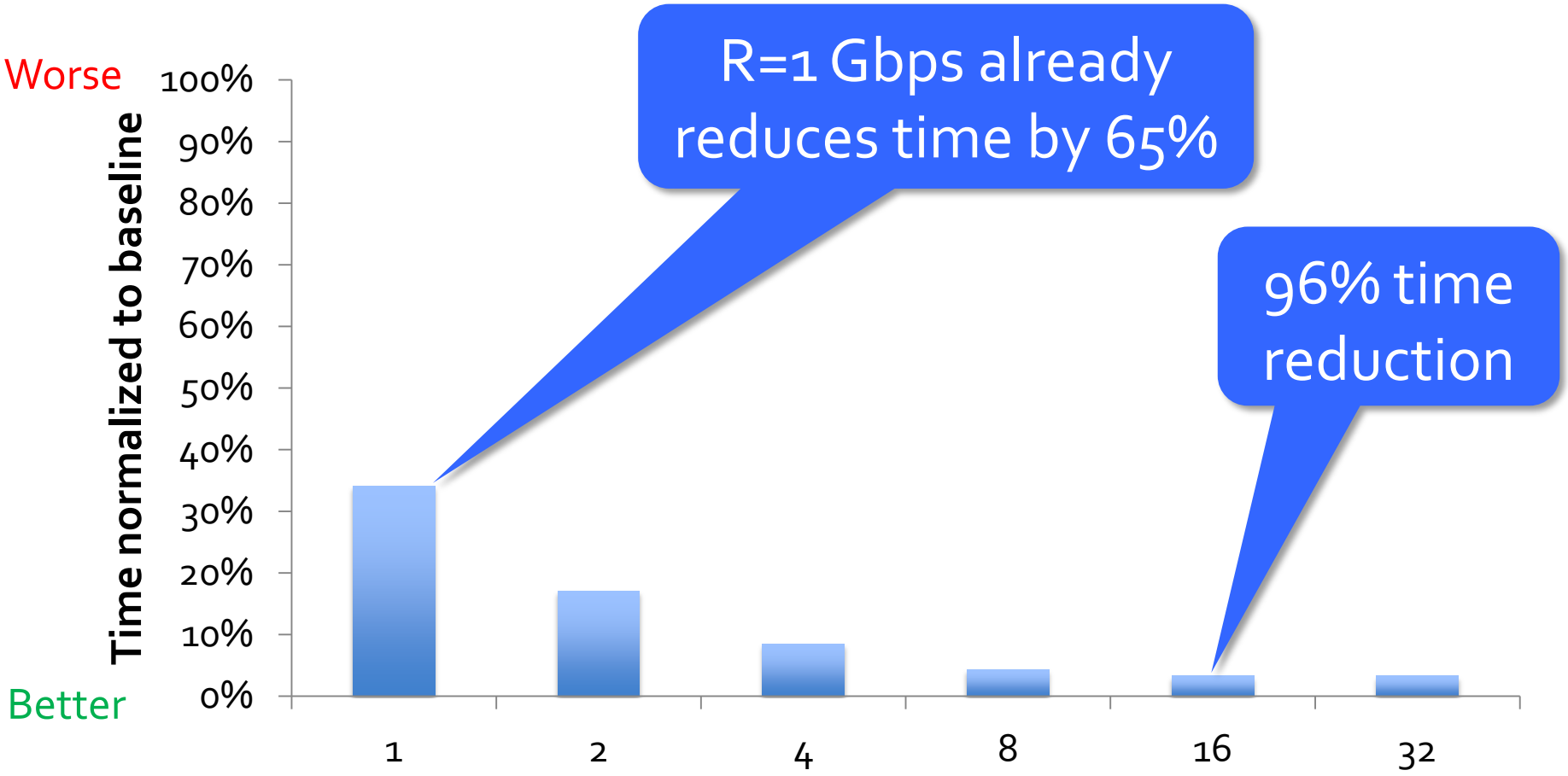
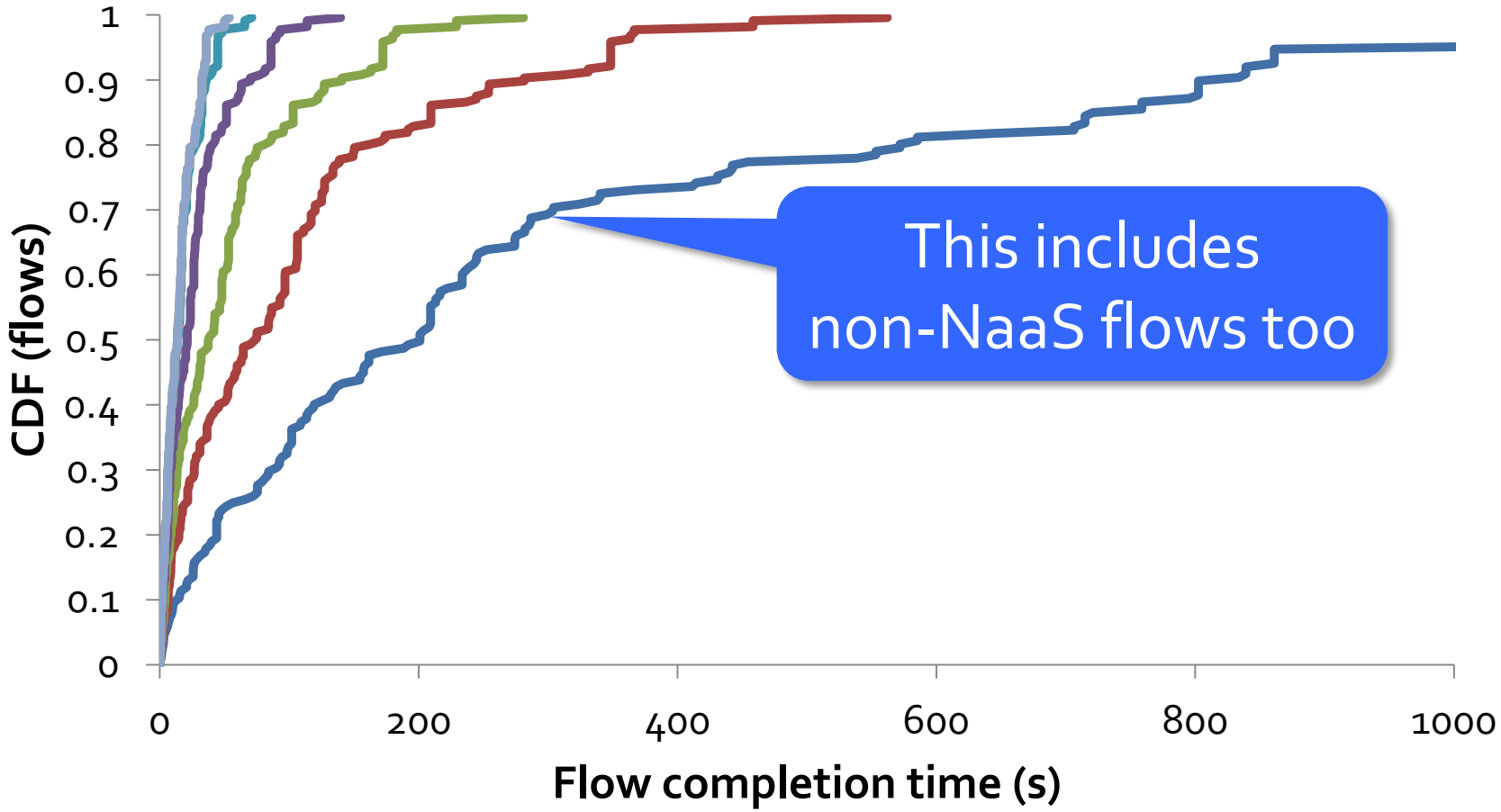


Even a low processing rate is enough to achieve significant benefits

Individual Flow Completion Time



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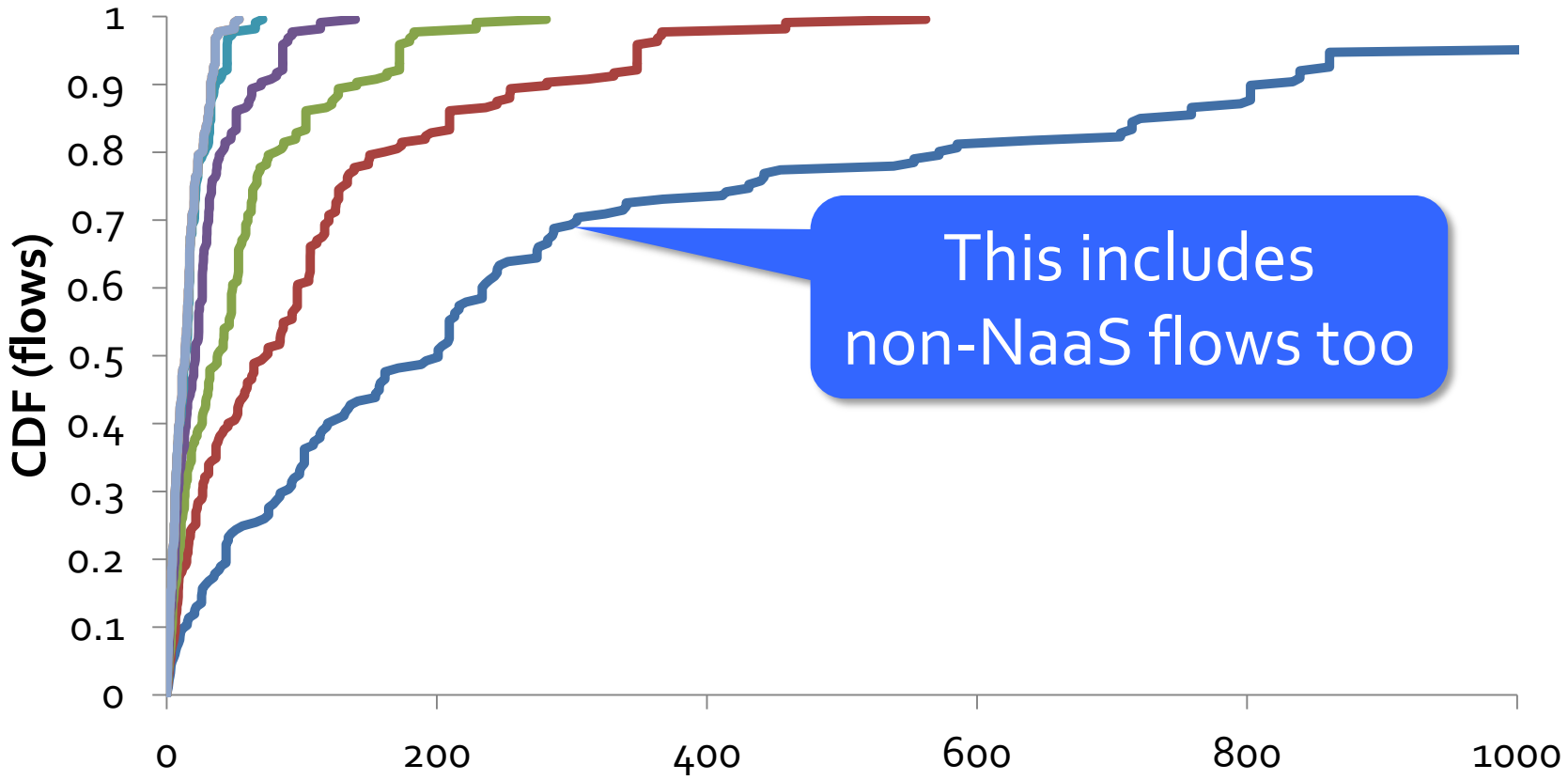

The use of NaaS is beneficial for all flows (including non-NaaS ones)

Challenges

- Scalability and performance isolation
  - Traditional software routers assume handful of trusted services
  - In NaaS we expect 10s or 100s of (potentially malicious or poorly written) INPEs per switch
- Programming abstractions
  - We should not expose the actual network programming
    - Too complex for many users
    - Sensitive information
  - Trade-off between flexibility and performance
- Pricing schemes
  - How we should charge tenants?

Summary

- Currently tenants have little control over the network
- NaaS focuses on enabling tenants to deploy applications within the network
  - ✓ Efficiency
  - ✓ Simplified development
  - ✓ Providers benefit too
- On-going work
  - SideCar[HotNets'11] inspired design
  - Transparent acceleration of mainstream applications