Georgia Institute of Technology

Software Defined Networking

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In this course, you will learn about software defined networking and how it is changing the way communications networks are managed, maintained, and secured.

School of Computer Science

Module 5.2: Programmable Data Plane

- Two Lessons
  - Programming the data plane: Click
  - **Scaling programmable data planes**
    - **Making software faster**
    - Making hardware more programmable
- **Optional** programming assignment (in Click)
- Quiz on Concepts

Motivation

- Many new protocols require data-plane changes.
  - Examples: OpenFlow, Path Splicing, AIP, …
- Protocols must forward packets at acceptable speeds.
- May need to run in parallel with existing protocols

- **Need:** Platform for developing new network protocols that
  - Forwards packets at high speed
  - Runs multiple data-plane protocols in parallel

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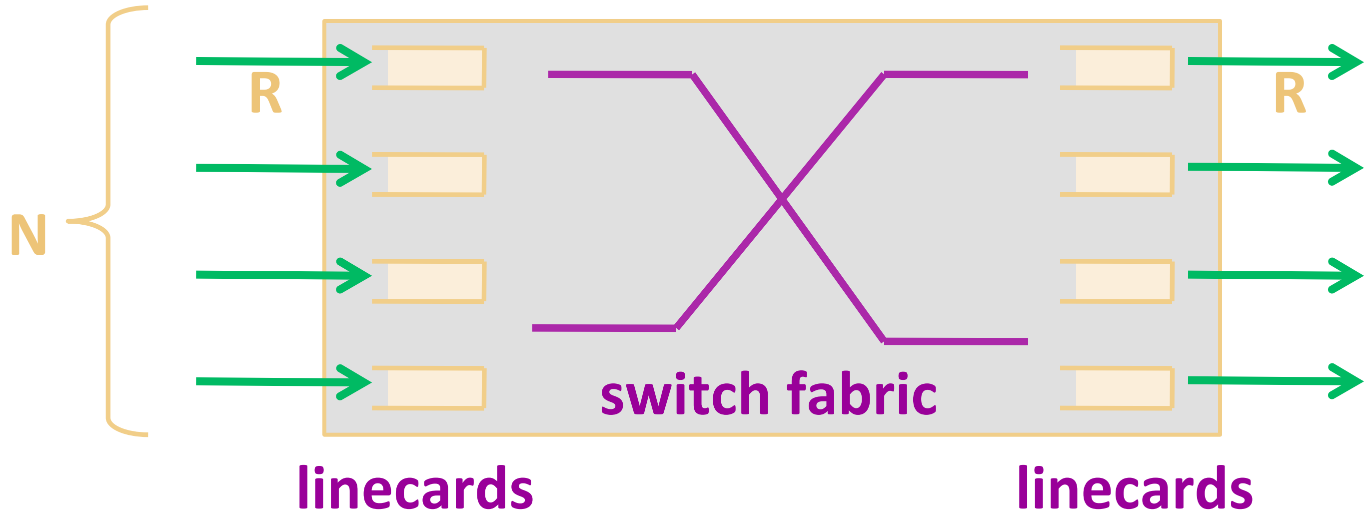
Existing Approaches

- Develop **custom software**
  - **Advantage:** Flexible, easy to program
  - **Disadvantage:** Slow forwarding speeds
- Develop modules in **custom hardware**
  - **Advantage:** Excellent performance
  - **Disadvantage:** Long development cycles, rigid
- Develop in **programmable hardware**
  - **Advantage:** Flexible and fast
  - **Disadvantage:** Programming is difficult

Hardware Router



- Processing at rate ~*R* per line card
- Switching at rate *N* x *R* by switch fabric

Dobrescu, Mihai, et al. "RouteBricks: exploiting parallelism to scale software routers." *Proceedings of the ACM SIGOPS 22nd symposium on Operating systems principles*. ACM, 2009.

RouteBricks: Linecards on Servers

- Processing at rate ~*R* per server
- Switching at rate ~*R* per server

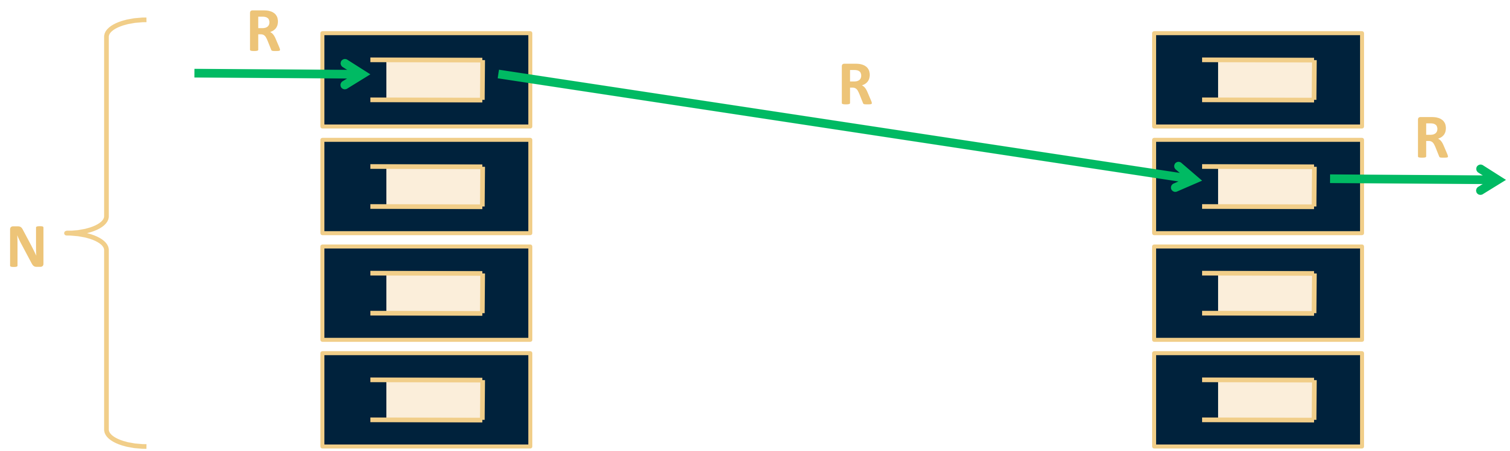
Requirements

- Internal link rates < *R*
- Per-server processing rate: *c* x *R*
- Per-server fanout: constant

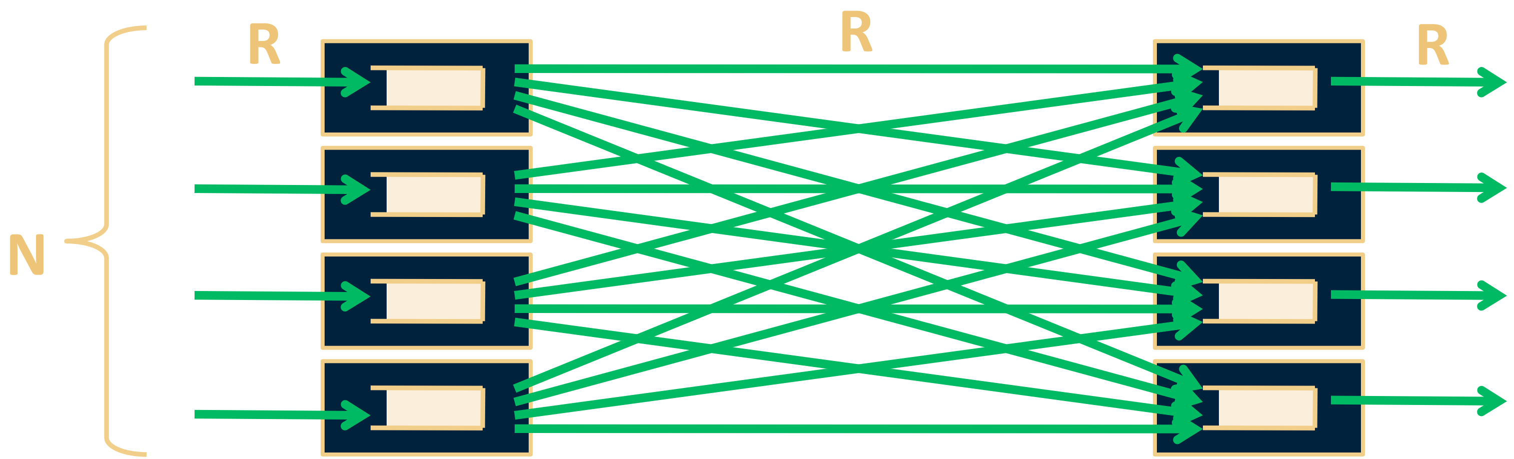
Challenges

- **Limited internal link rates:** Internal links can't exceed external link rates
- **Limited per-node processing rate:** Desire to use commodity hardware
- **Limited per-node fanout:** Due to limited NIC slots/ports

Strawman Approach

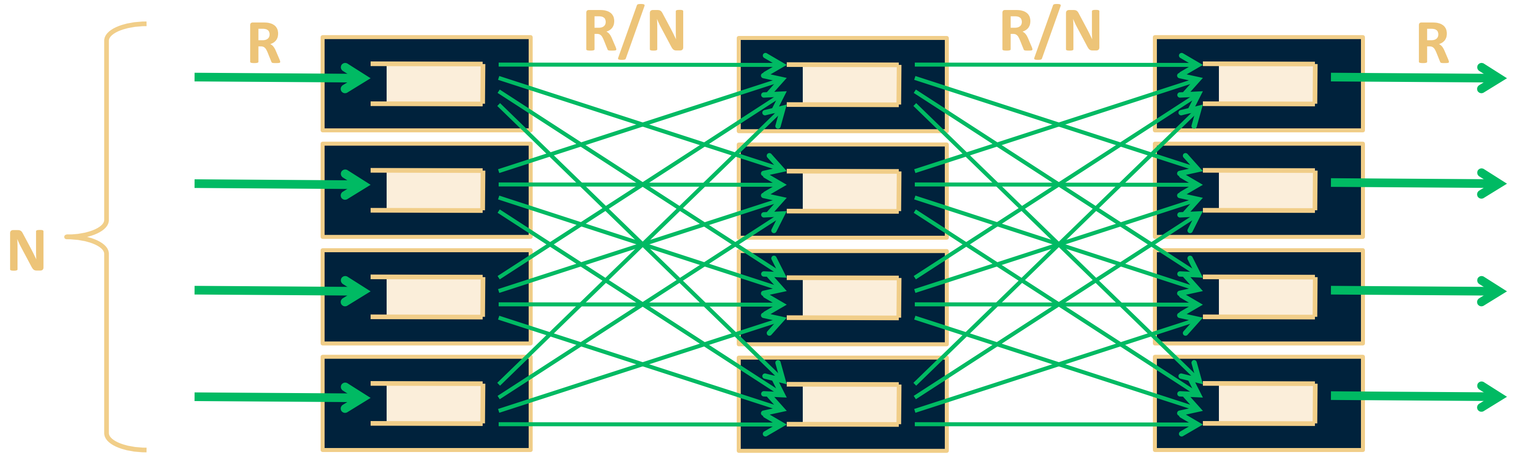


Strawman Approach



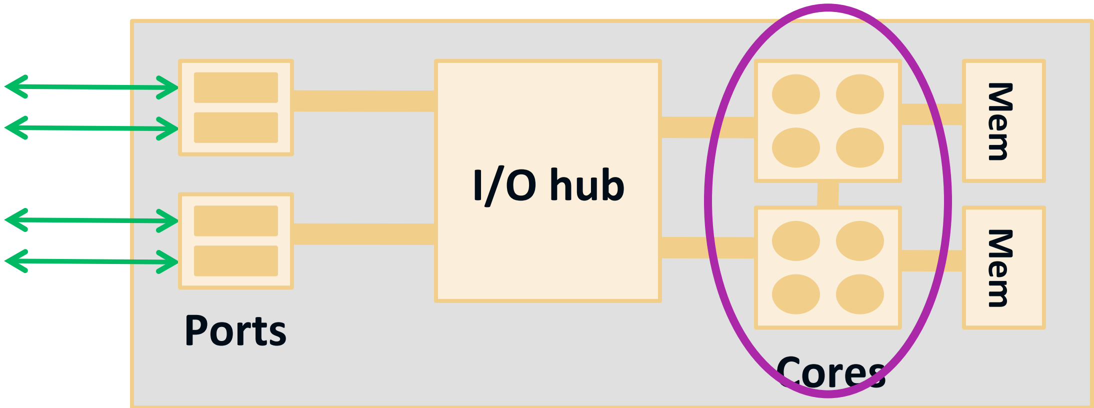
- N external links of capacity R
- N^2 internal links of capacity R

Valiant Load Balancing



- Per-server processing rate: 3*R*
- With uniform traffic (avoiding first phase): 2*R*

Each Server Must Also Be Fast

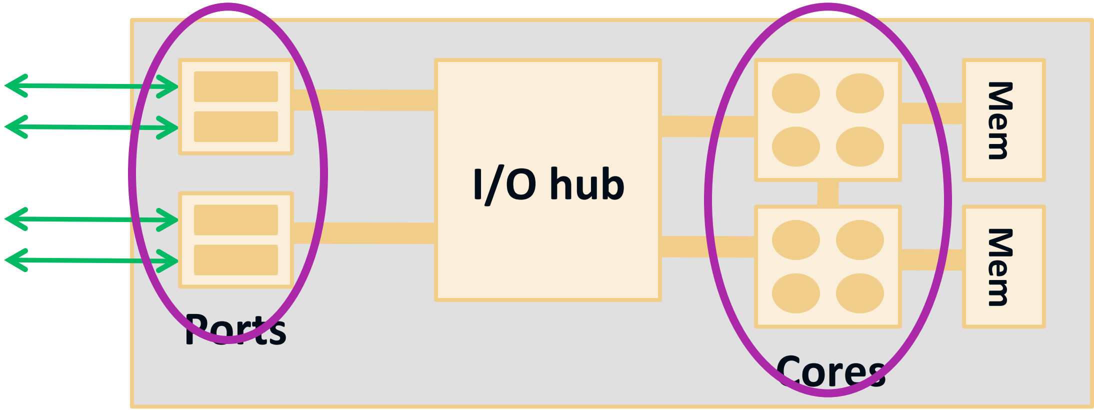


- First try: 1.3 Gbps

Problem #1: Bookkeeping

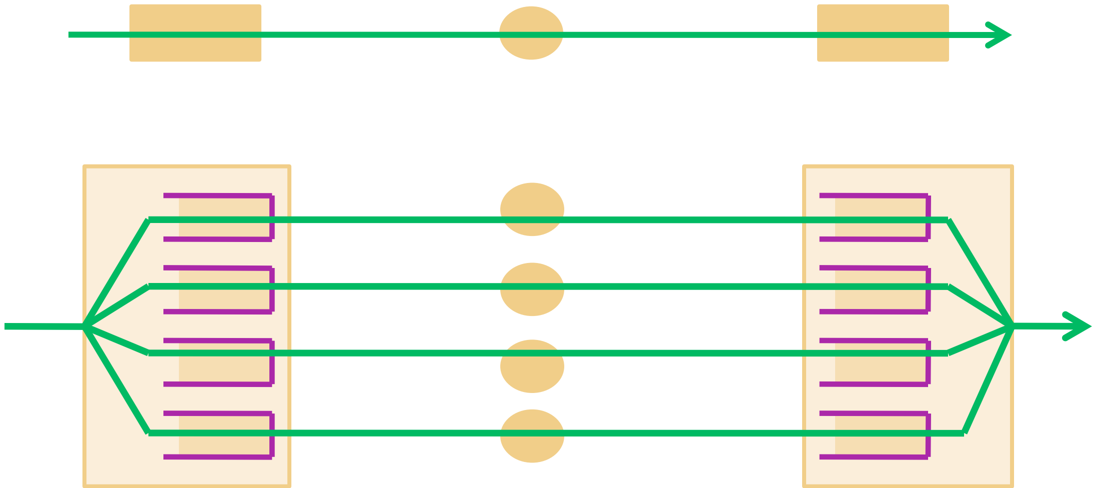
- **Managing packet descriptors**
  - moving between NIC and memory
  - updating descriptor rings
- **Solution: batch packet operations**
  - NIC batches multiple packet descriptors
  - CPU polls for multiple packets
  - Cost: increased latency

Single-Server Performance



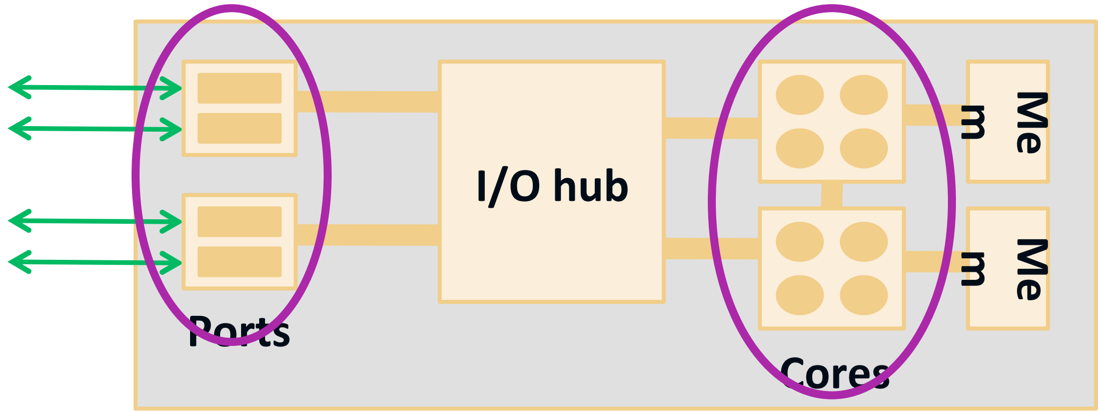
- First try: 1.3 Gbps
- With batching: 3 Gbps

Problem #2: Queue Access



- Rule #1: 1 core per queue (avoids locking)
- Rule #2: 1 core per packet (faster)

Single-Server Performance



- **First try:** 1.3 Gbps
- **With batching:** 3 Gbps
- With multiple queues: **9.7 Gbps**

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Fast Software Forwarding: Other Tricks

- Large packet buffers to hold multiple packets
- Batch processing
- Ethernet GRE (to avoid complicated lookup)
- Avoiding lookups on bridge between virtual interfaces and physical interfaces

Han, Sangjin, et al. "PacketShader: a GPU-accelerated software router." *ACM SIGCOMM Computer Communication Review* 40.4 (2010): 195-206.
Bhatia, Sapan, et al. "Trellis: A platform for building flexible, fast virtual networks on commodity hardware." *Proceedings of the 2008 ACM CoNEXT Conference*. ACM, 2008.

Summary

- **Scalability: Make the software faster**
  - **Software routers can be fast!**
- General purpose infrastructure is capable of fast forwarding performance
  - The low-level details, optimizations matter
- Other efforts underway
  - Intel DPDK