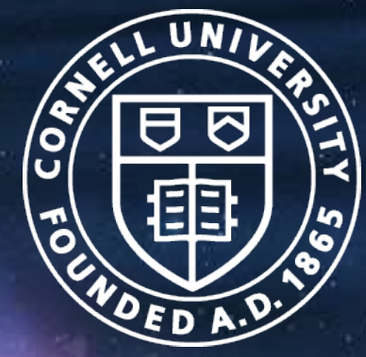
Universal Scheduling Mechanisms

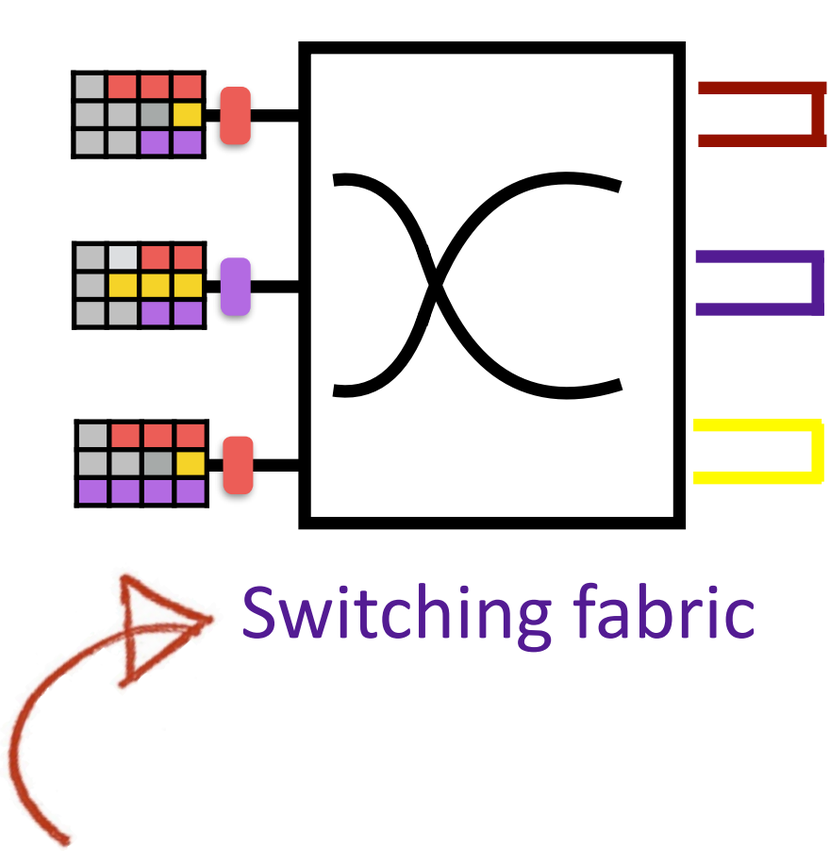


Rachit Agarwal
Cornell University (starting Fall)

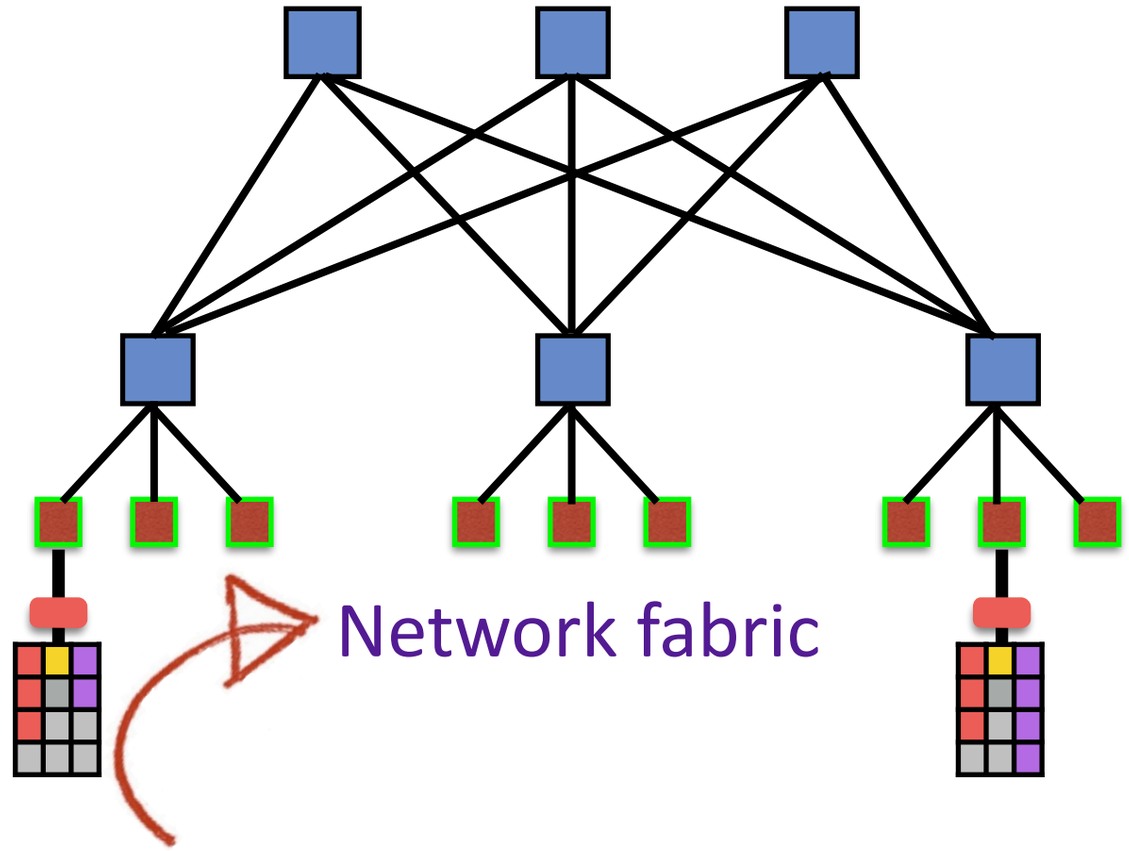
Network Task

Delivering data from source(s) to corresponding destination(s)

- Policies (e.g., resource sharing)
- Performance metrics (e.g., latency, throughput)

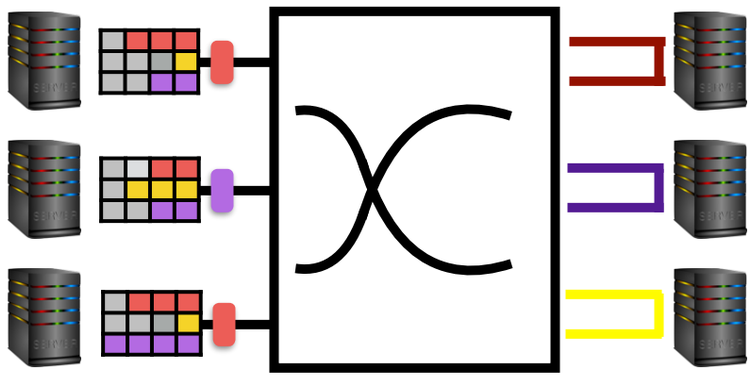


Which packet to schedule next? (Packet scheduling)

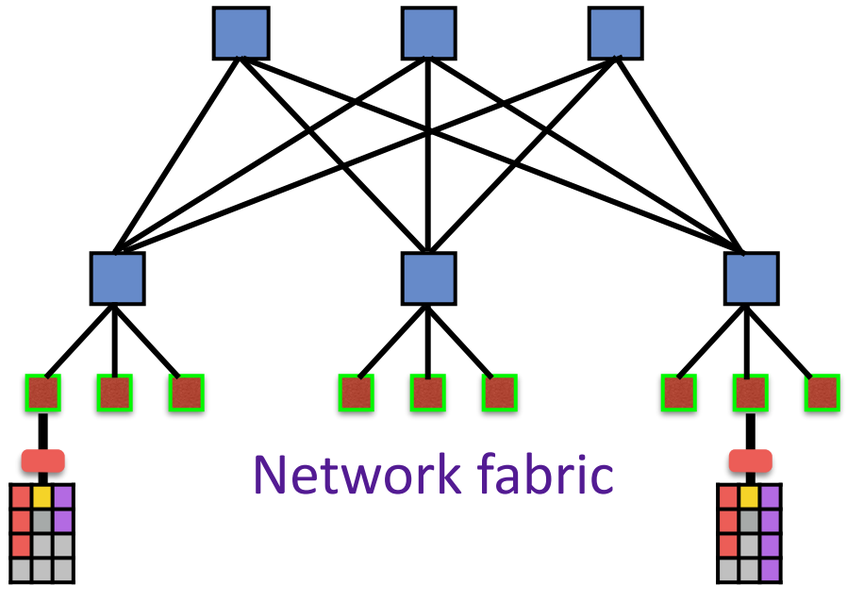


Which flow to schedule next? (Flow scheduling)

Delivering flows and packets



Switching fabric



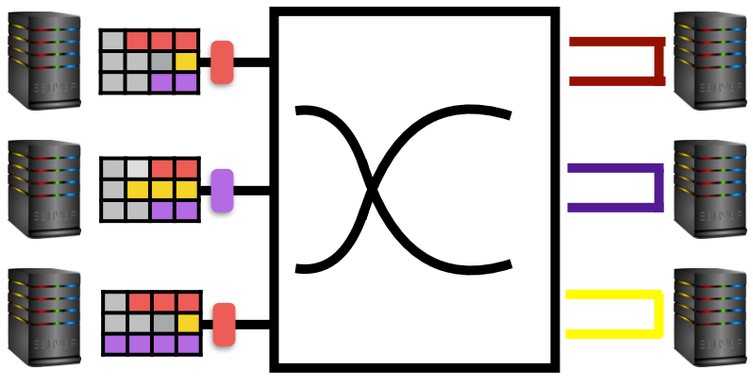
Network fabric

Great area to ~~write papers~~ do research

- Ever-evolving metrics (latency, tail latency, deadlines, ….)
- … workloads (flows, short flows, coFlows, ….)
- … contexts (WAN, datacenters, cellular, ….)
- … trends (new/commodity hardware, centralized, distributed, ….)

Choose a random permutation!

Questions …



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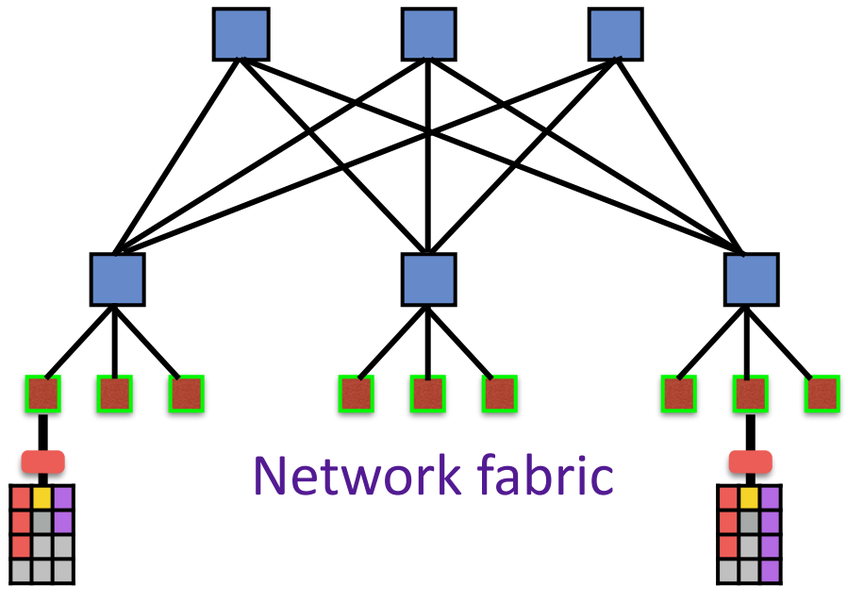

Network fabric

Question 1: new near-optimal mechanism for a **new objective**?

- FIFO, FIFO+, LIFO, Round Robin, FQ, ….
- TCP, DCTCP, D2TCP, D3, PDQ, Fastpass, pFabric, pHost, PIAS, PASE, ….

Question 2: how to support **different mechanisms?**

- Change hardware for each new mechanism?
- Programmable network hardware?
  - The *set of abstractions* for each and every possible mechanism?

Questions …

~~**Question 1: new** near-optimal mechanism for a **new objective**?~~

~~**Question 2:** how to support **different mechanisms** for **different objectives?**~~

Question:

one near-optimal mechanism for **all objectives**?

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one near-optimal mechanism for **all objectives**?

P4 and the RMT switch

- no abstractions and implementations for scheduling
- **Right time** to ask the question!

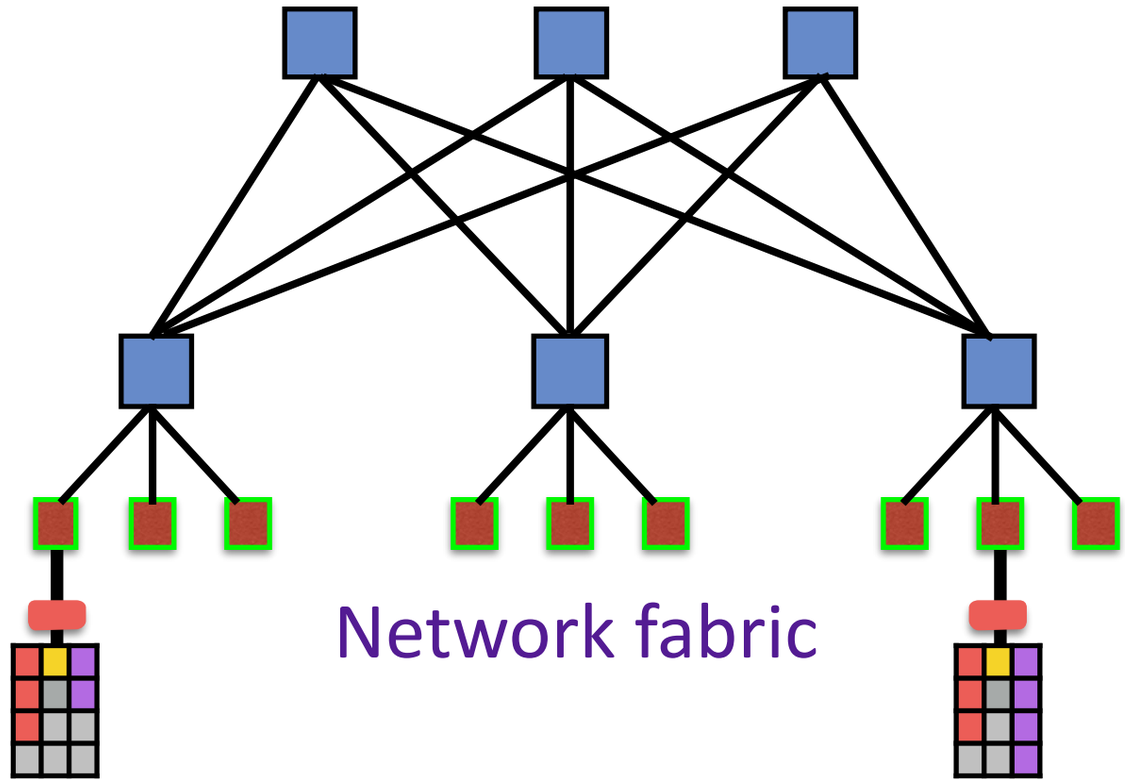
NO: we **need** to design new mechanisms with new objective

- Programmable *packet schedulers* a necessity
- Focus on designing the set of abstractions

YES: changes the **lens through which we view** scheduling mechanisms

- **one abstraction**: simplified network programming
- is it cheaper to implement than the universal mechanism?

Universal Scheduling Mechanism: Feasibility?



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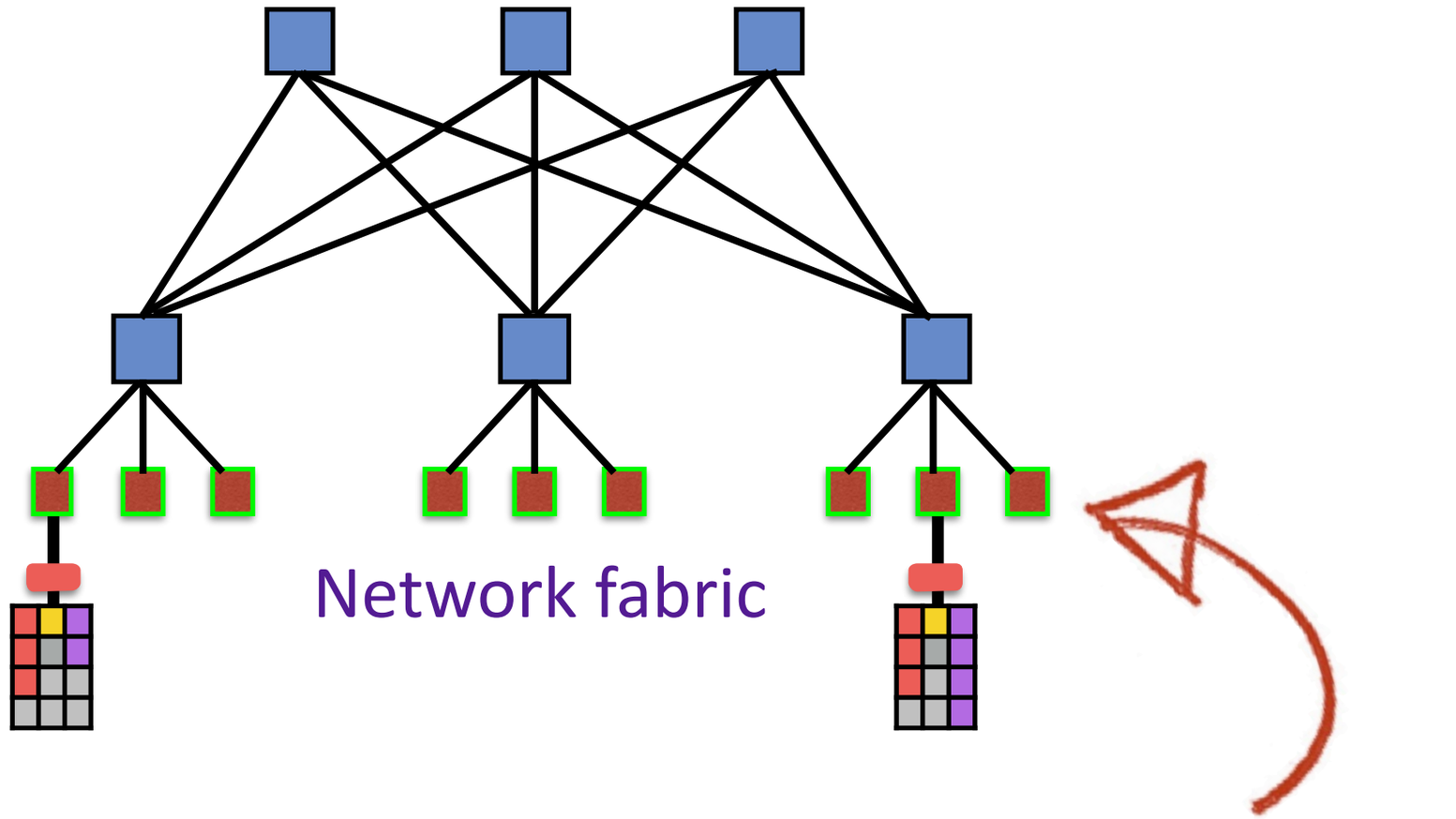

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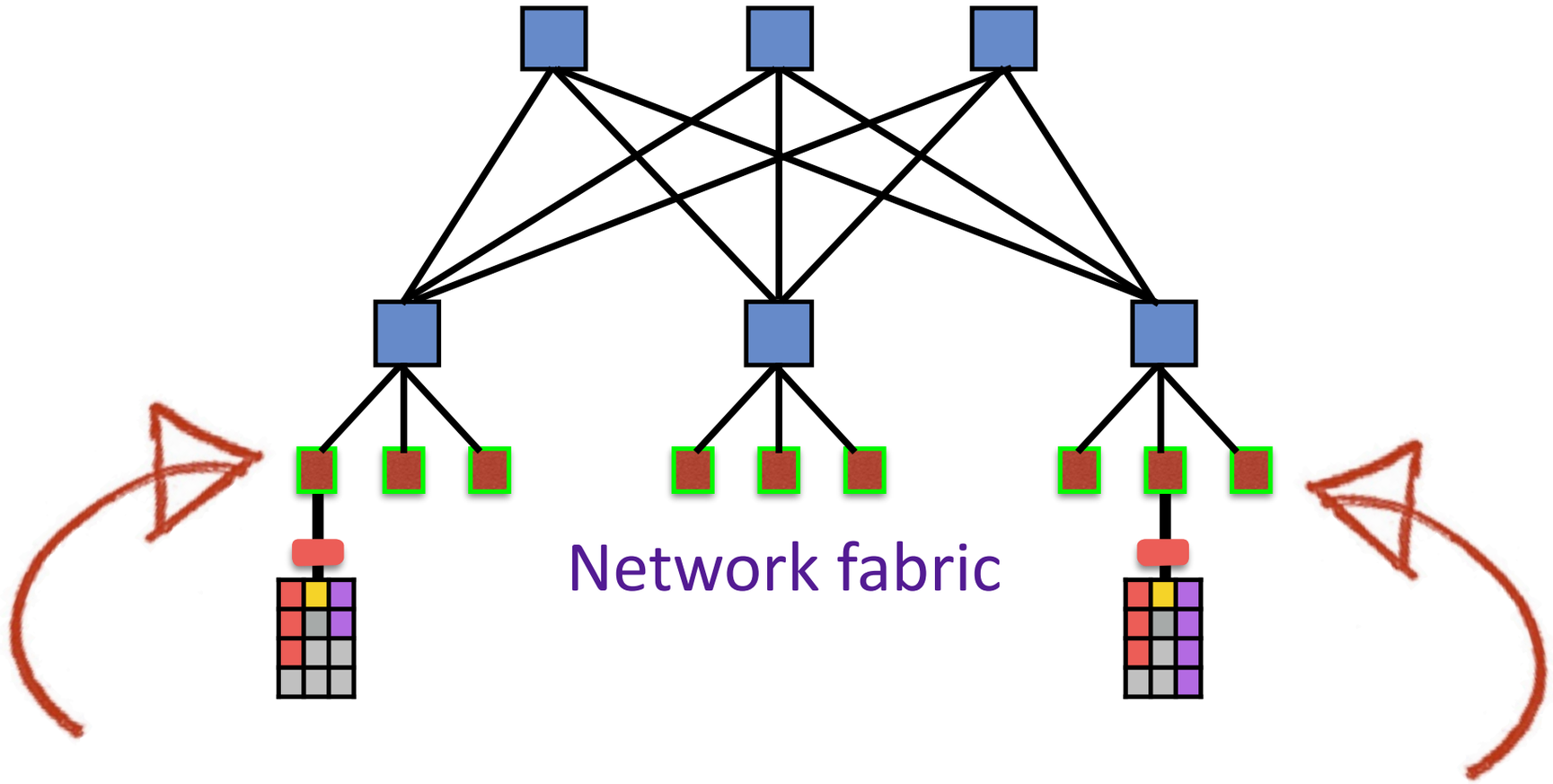
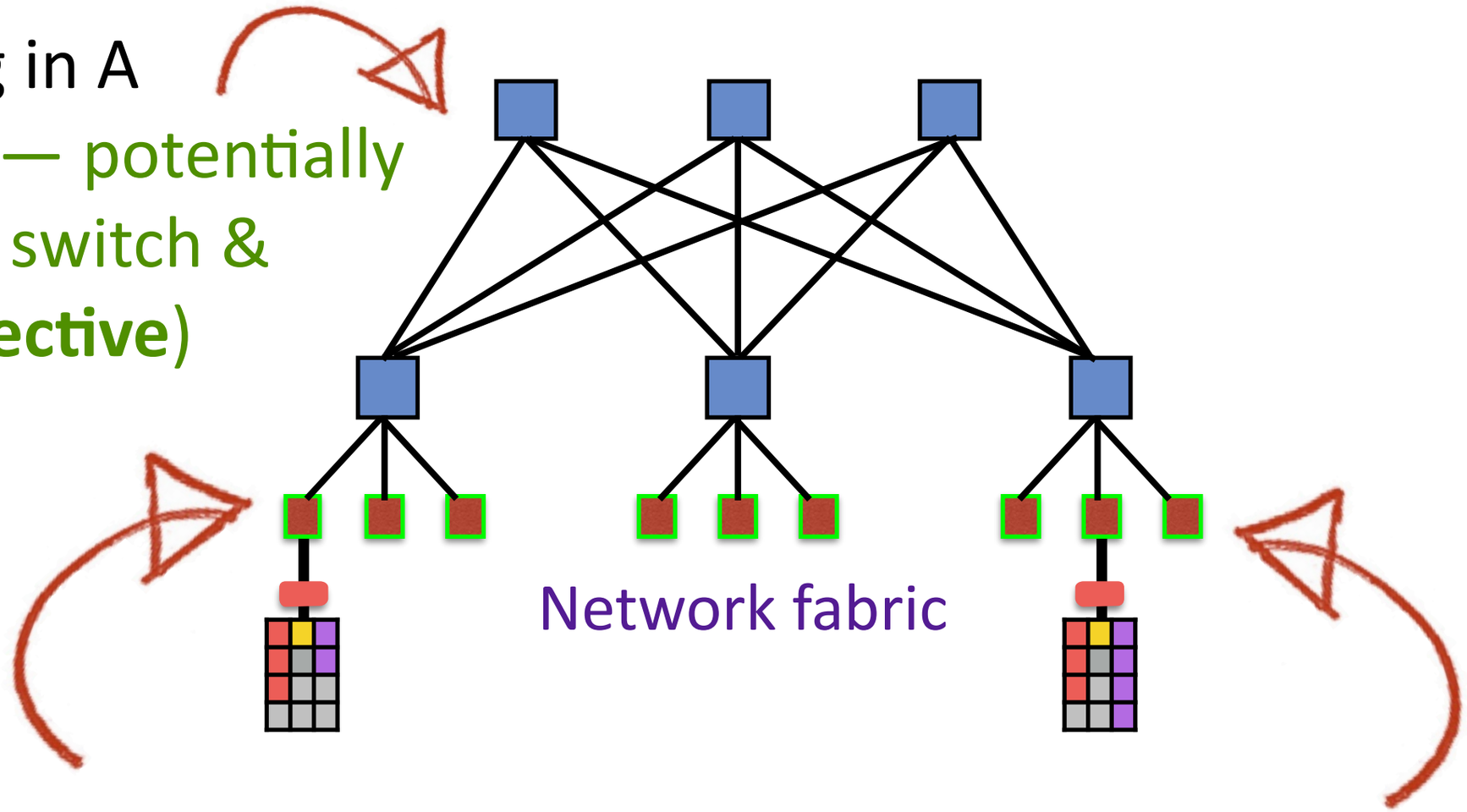


Packet header initialization
(Priority, flow size, flow weight, ..
—**based on the objective**)

Packet output timing
(at egress)

Universal Scheduling Mechanism: Feasibility?

Packet scheduling in A
(switch decisions — potentially different for each switch & **based on the objective**)



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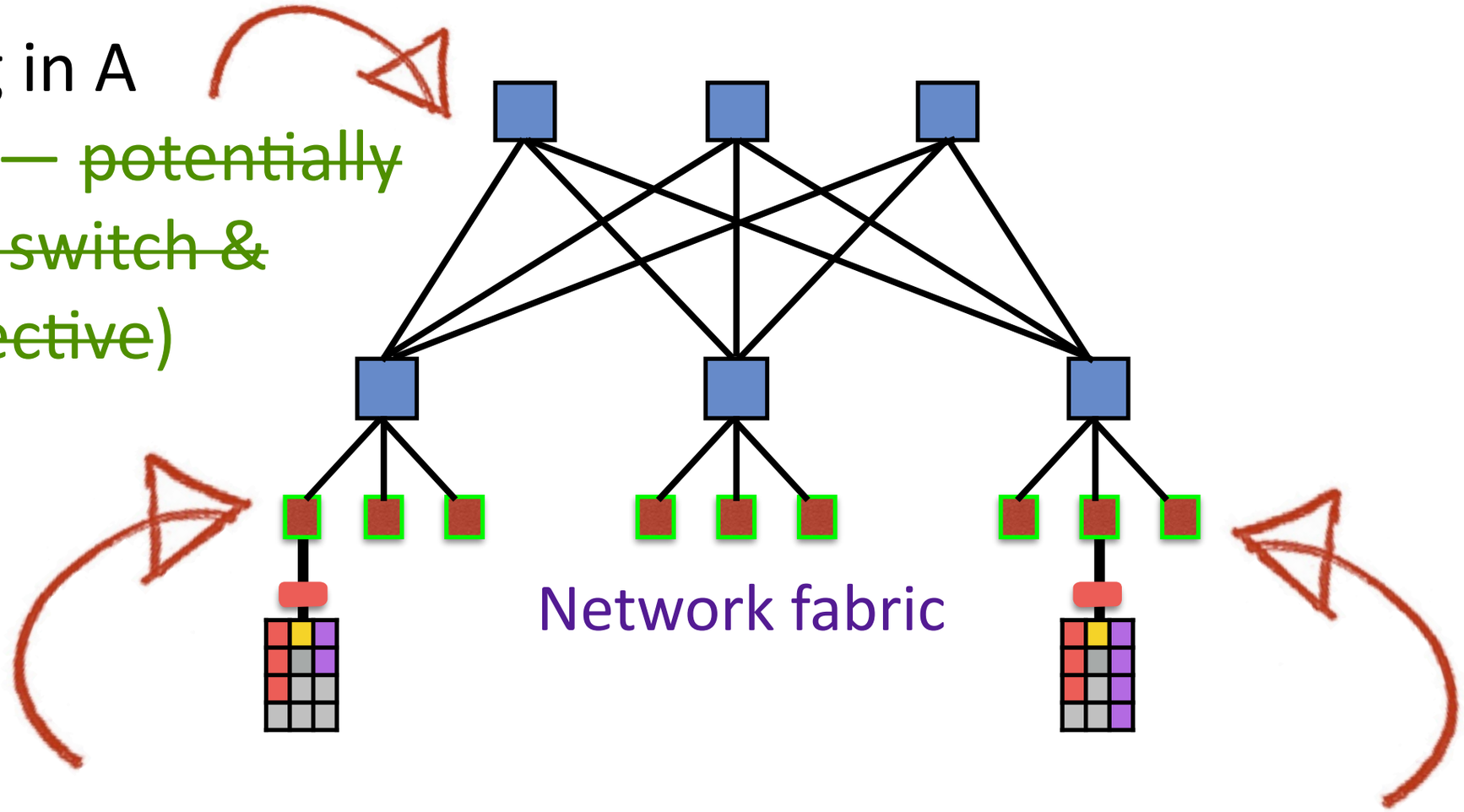

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Universal Scheduling Mechanism: Definition

Given

- any network topology
- any workload (set of flows, their arrival times, and paths)
- any objective function
- each switch may keep infinite state, and implement any logic
- An optimal scheduling algorithm A

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The Universal Scheduling Mechanism should

- produce packet timing at the egress same as A for each packet
- with each switch implementing the same logic
- without keeping any additional state

Universal Scheduling Mechanism: Preliminary results

There exists a Universal Scheduling Mechanism

- except for flows that encounter more than two congestion points

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Header initialization

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Switch logic

- Enqueue
- Dequeue: Least Slack First
- Reduce slack value by "waiting time"
- **Just need Pipelined-heap implementation**

Universal Scheduling Mechanism: Open problems (1)

Our current constraints:

- any network topology
- any workload (set of flows, their arrival times, and paths)
- any objective function
- each switch may keep infinite state, and implement any logic
- An optimal scheduling algorithm A

Relax the constraints

- What if a few packets are allowed to be delayed?
- Approximation algorithms?
- Randomized algorithms?
- What if the switches have limited buffers?

Universal Scheduling Mechanism: Open problems (2)

Other questions

- Active Queue Management
- Multiple objective functions sharing the fabric
    - Each flow may have its own goal
- Guarantees in presence of failures
- Implementation issues?

Feedback?

rachit @ cornell