Study the past if you would define the future*:

Secure Multi-Party SDN Updates

Liron Schiff

Tel Aviv University, Israel

Stefan Schmid

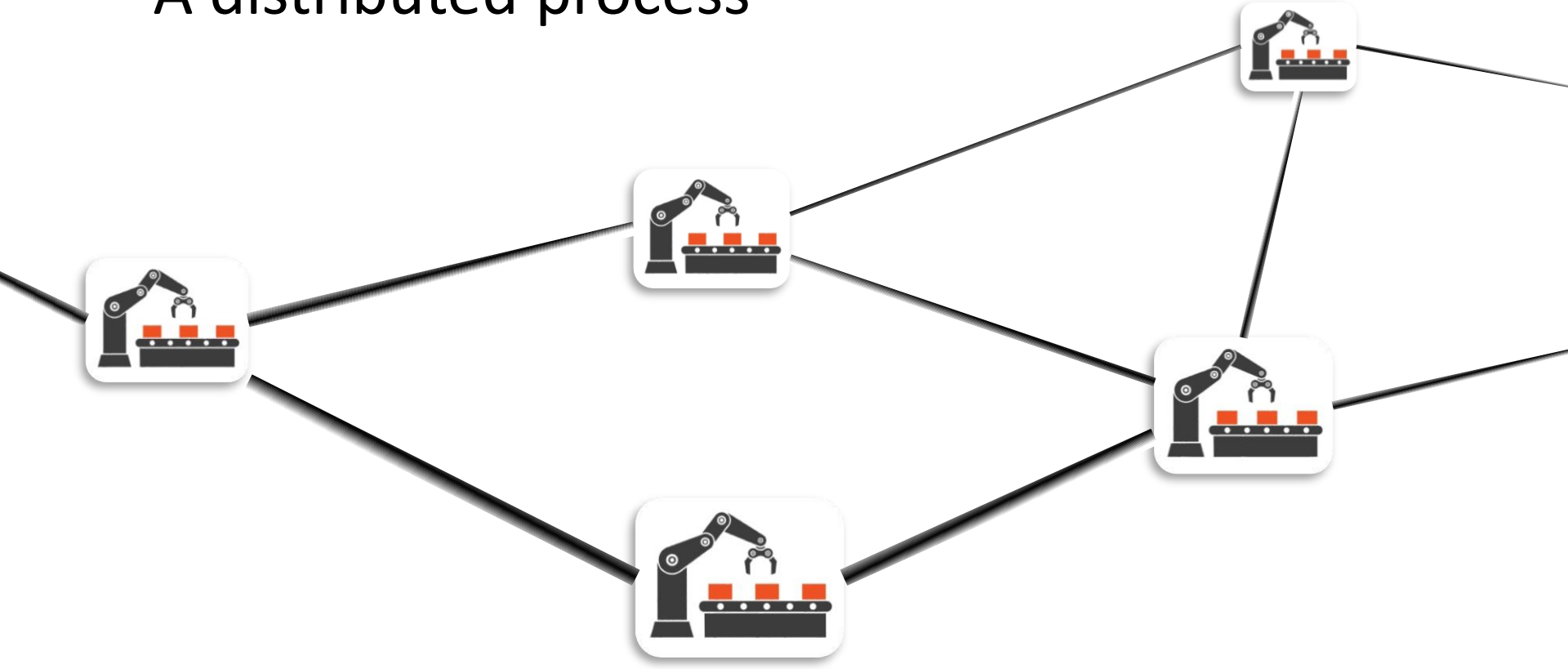
Aalborg University, Denmark

TU Berlin, Germany

*Confucius

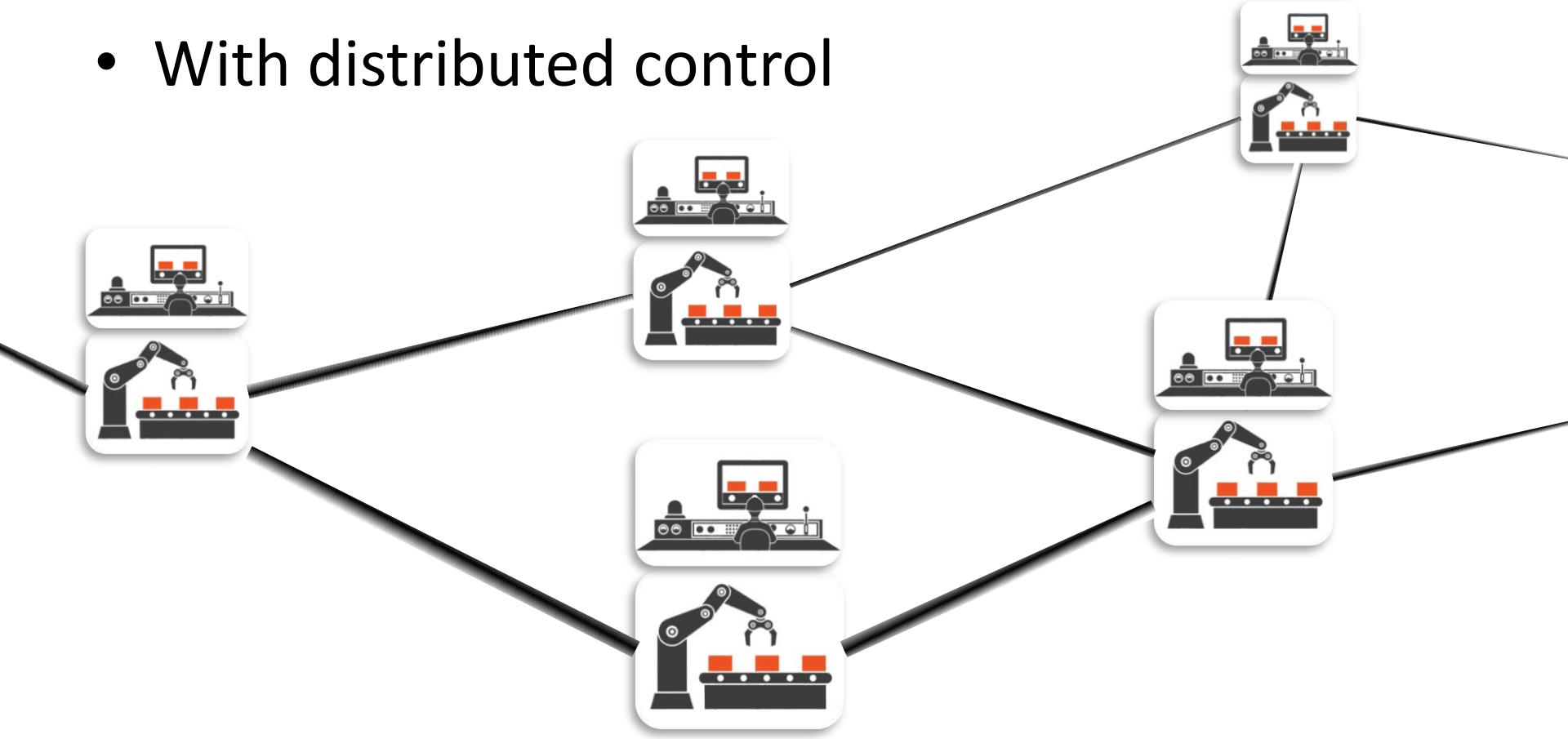
Routing Network

- A distributed process



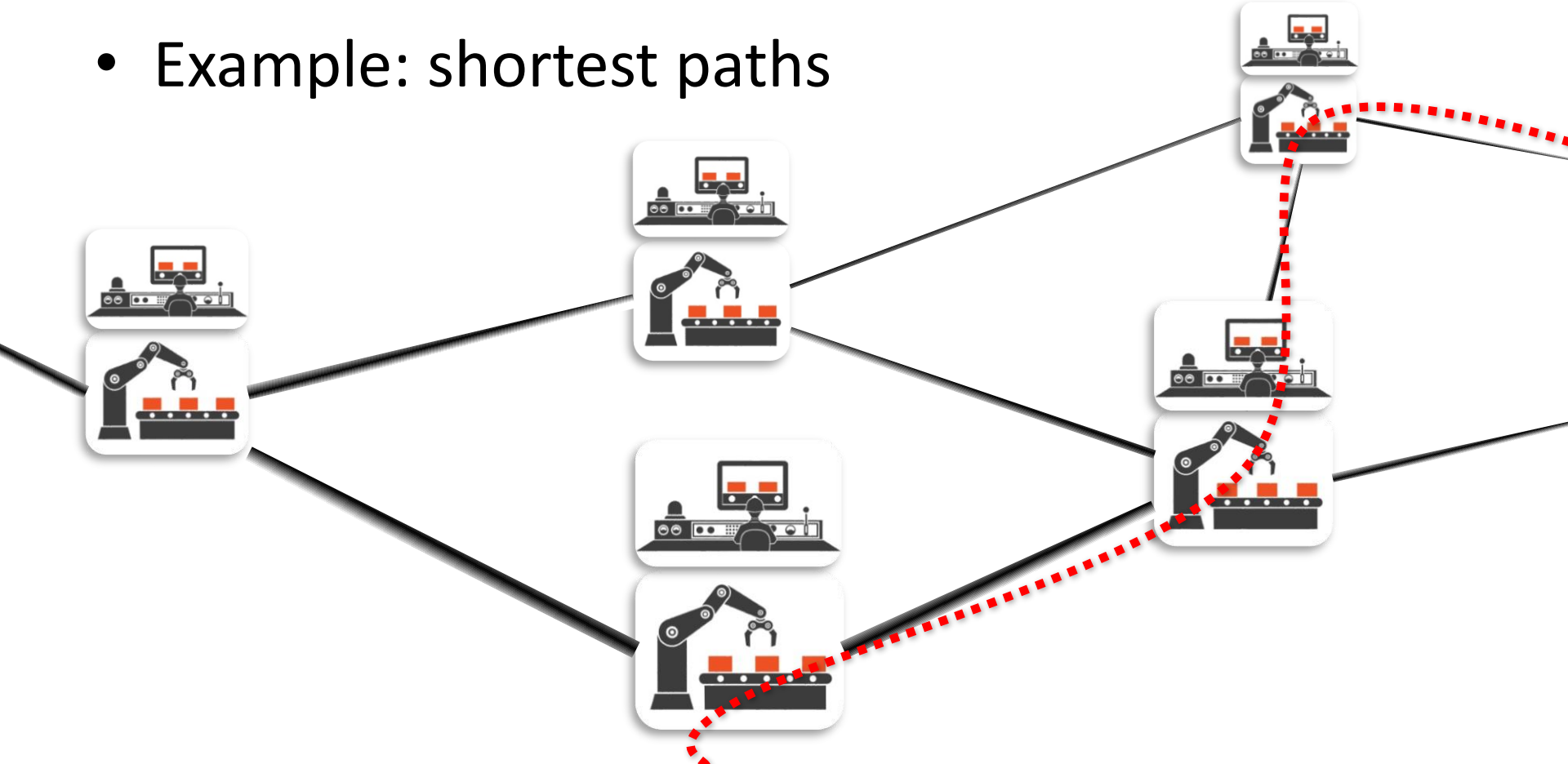
Routing Network

- With distributed control



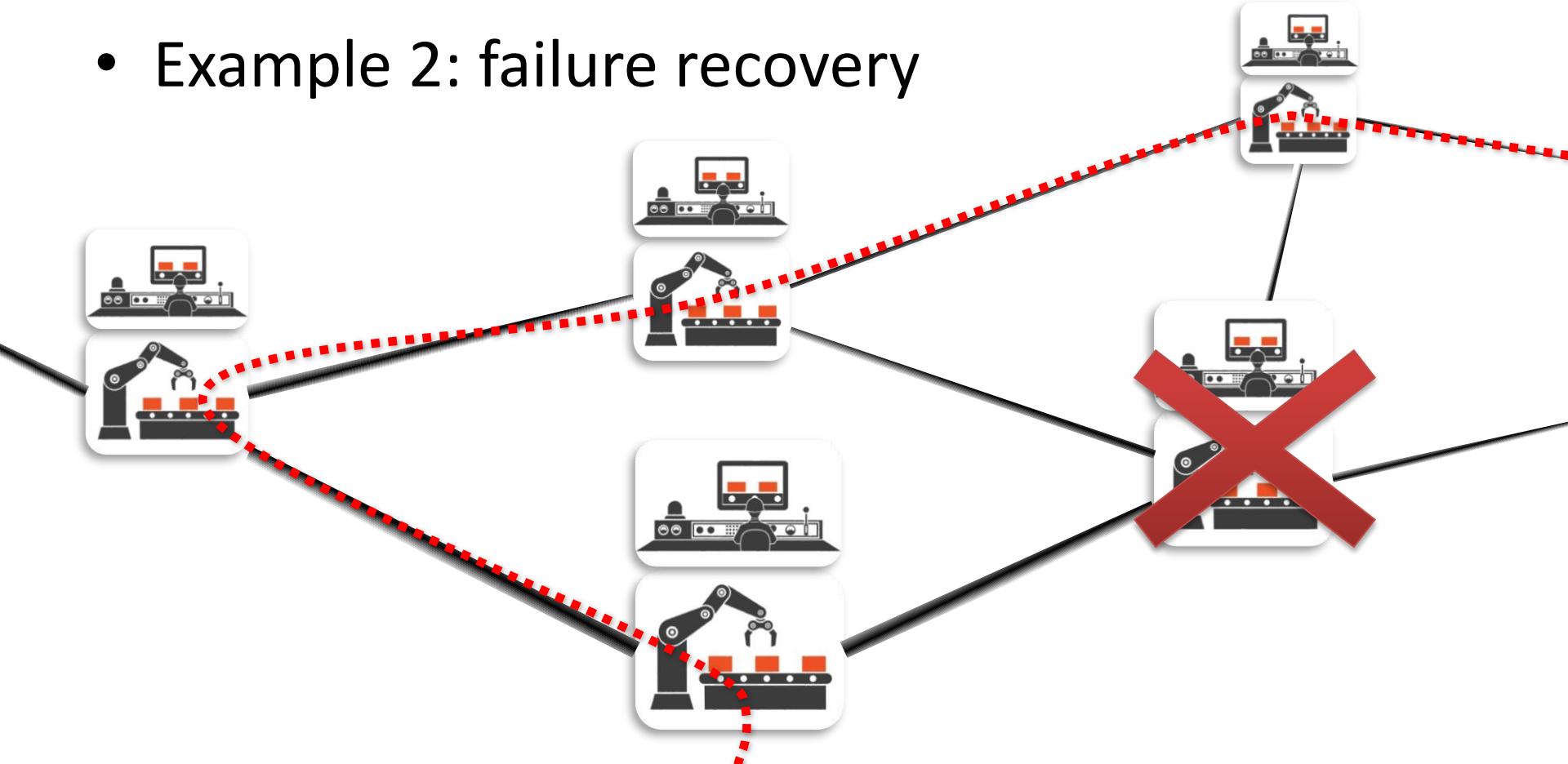
Routing Network

- Example: shortest paths



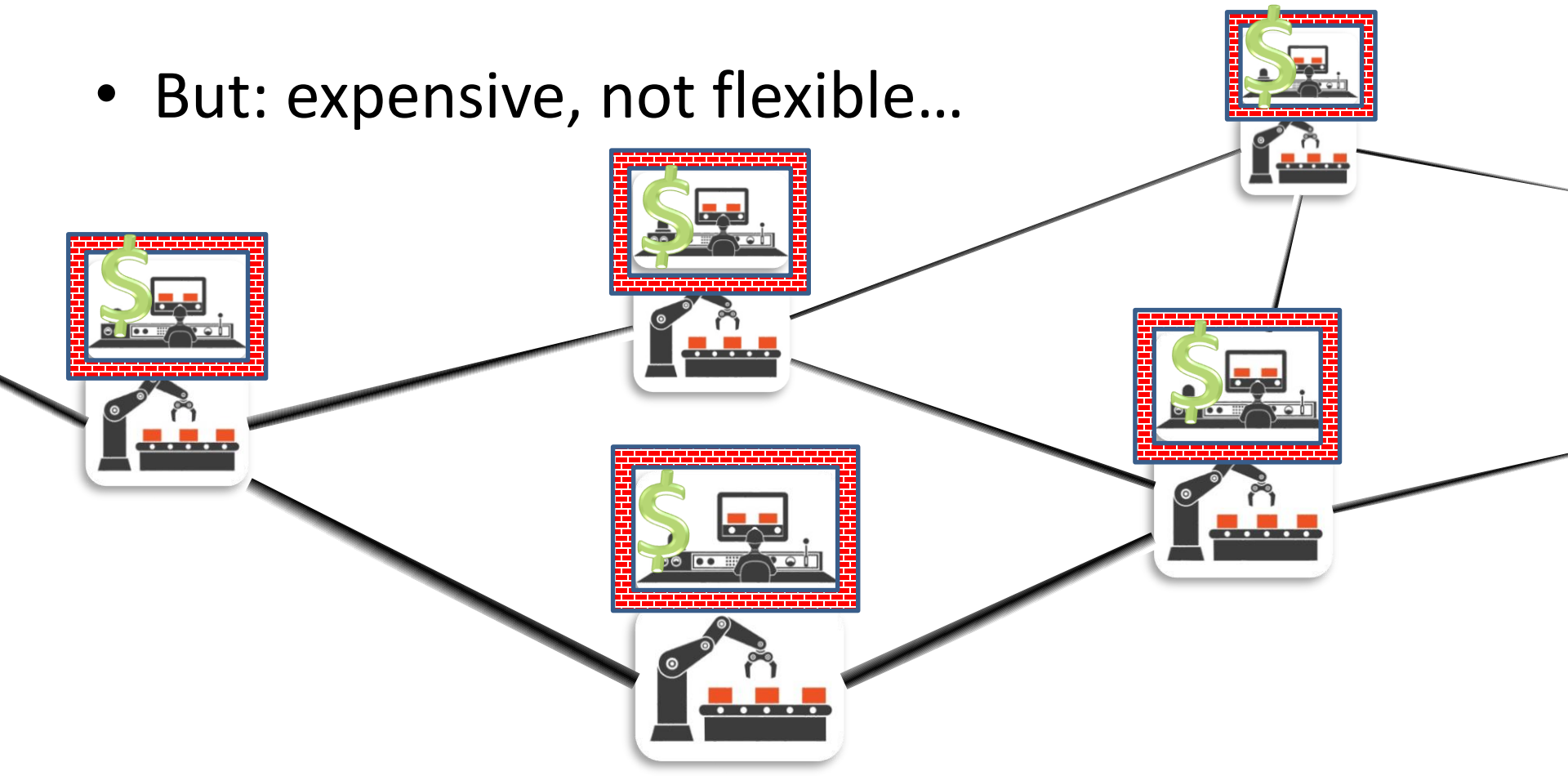
Routing Network

- Example 2: failure recovery



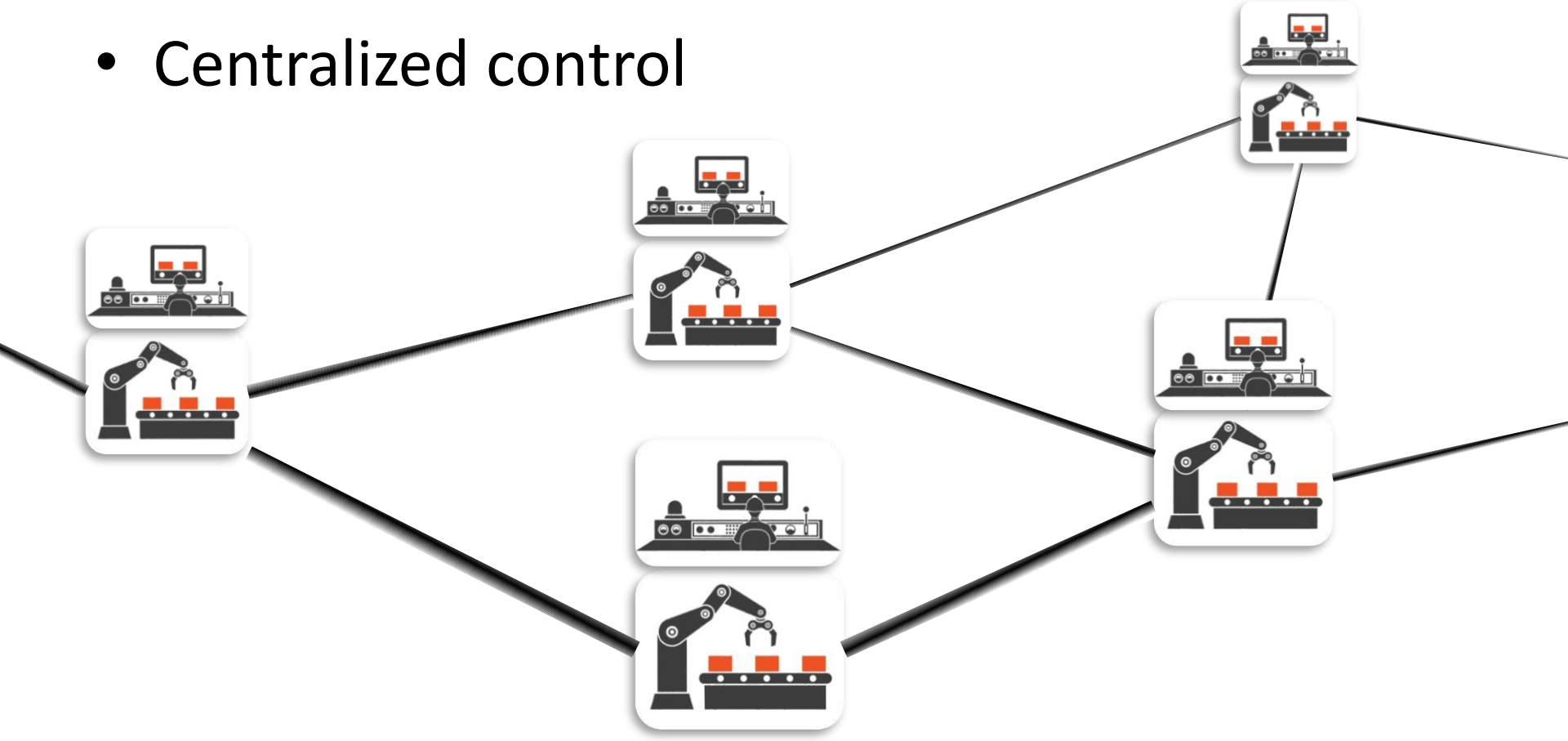
Routing Network

- But: expensive, not flexible…



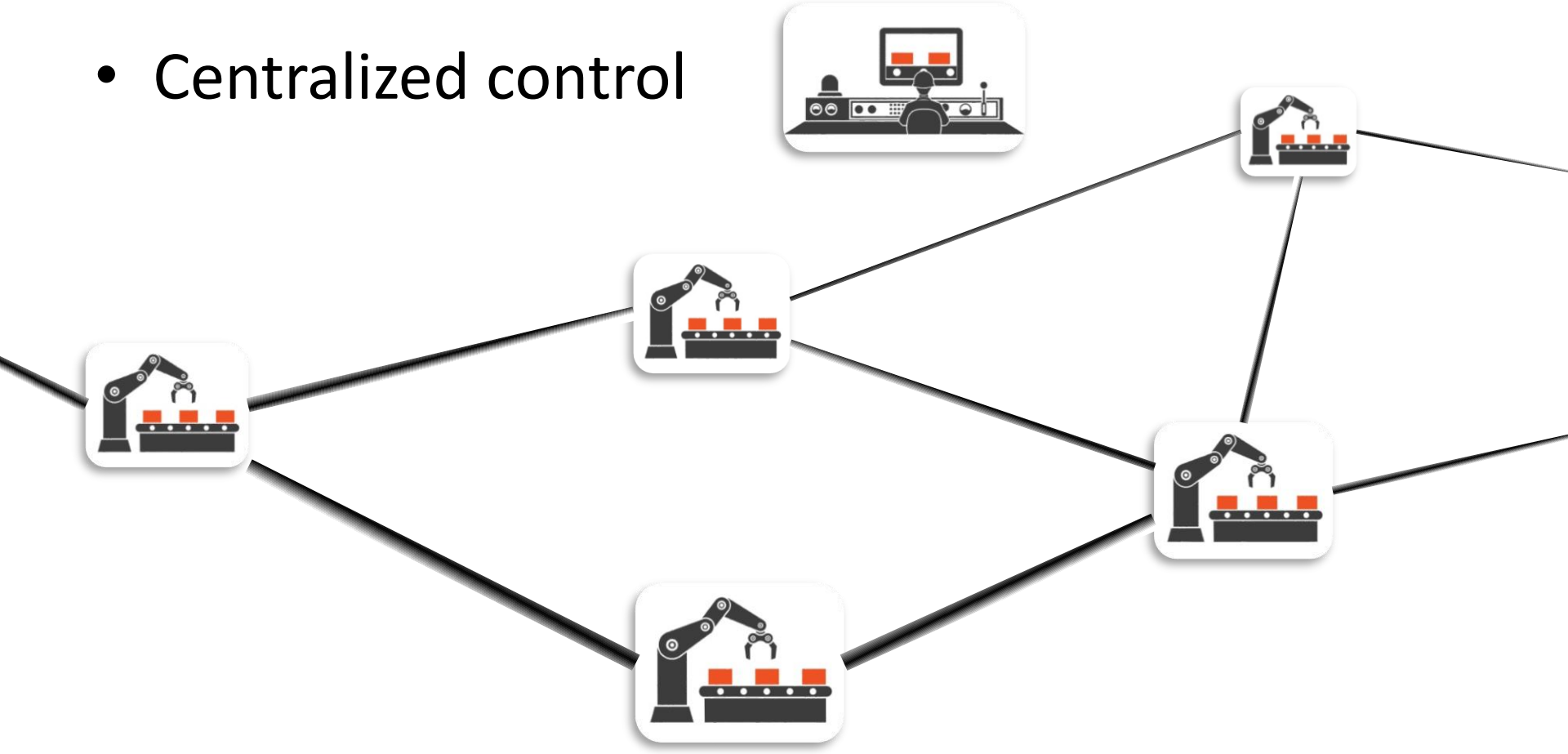
Software Defined Network (SDN)

- Centralized control



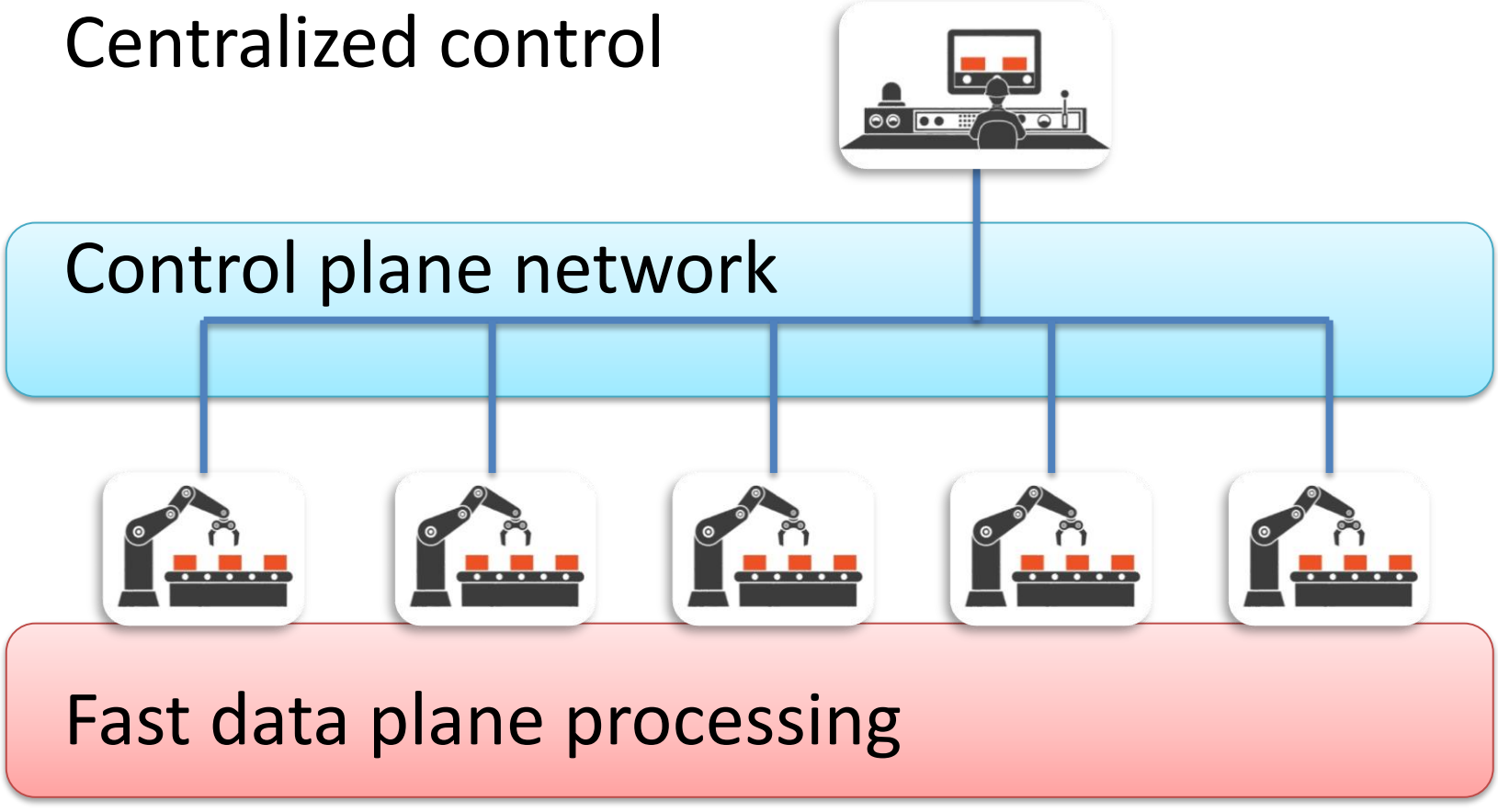
Software Defined Network (SDN)

- Centralized control



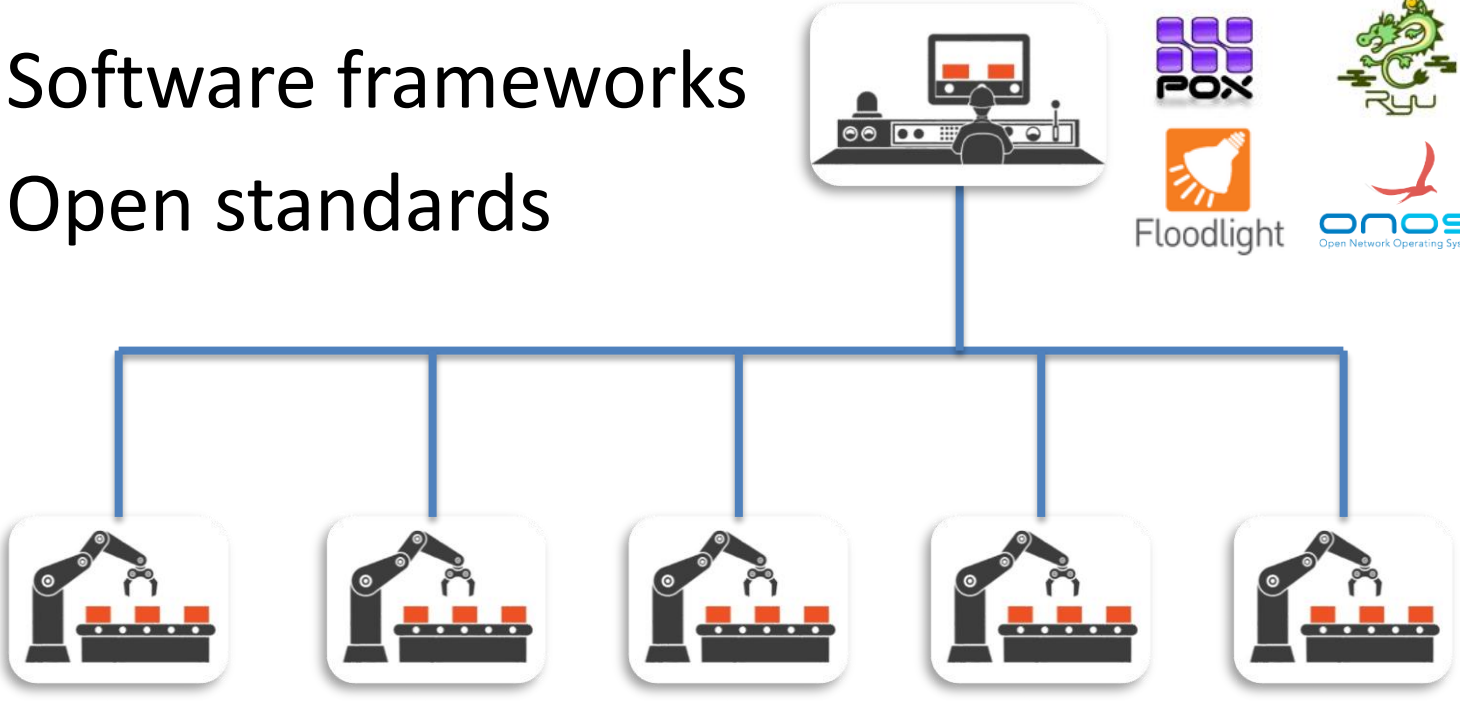
Software Defined Network (SDN)

Centralized control



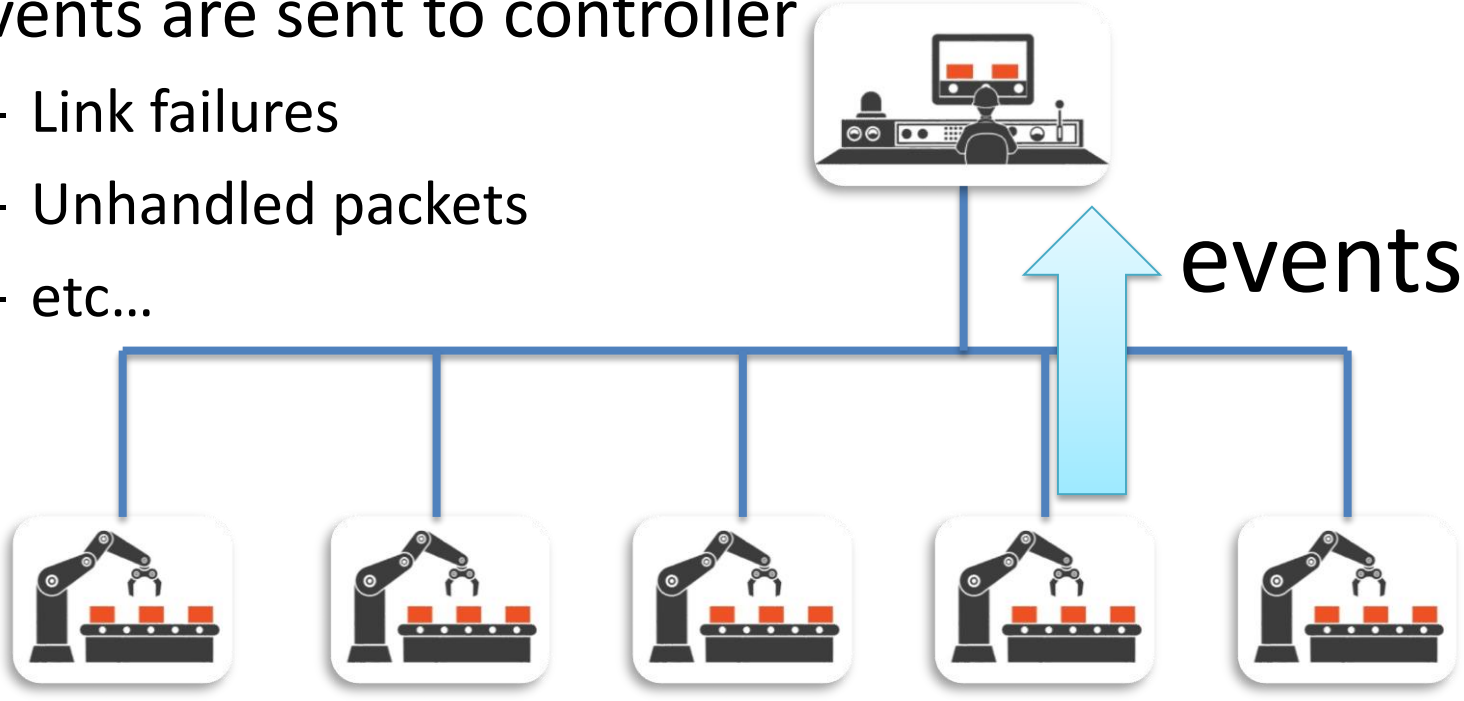
Software Defined Network (SDN)

- Software frameworks
- Open standards



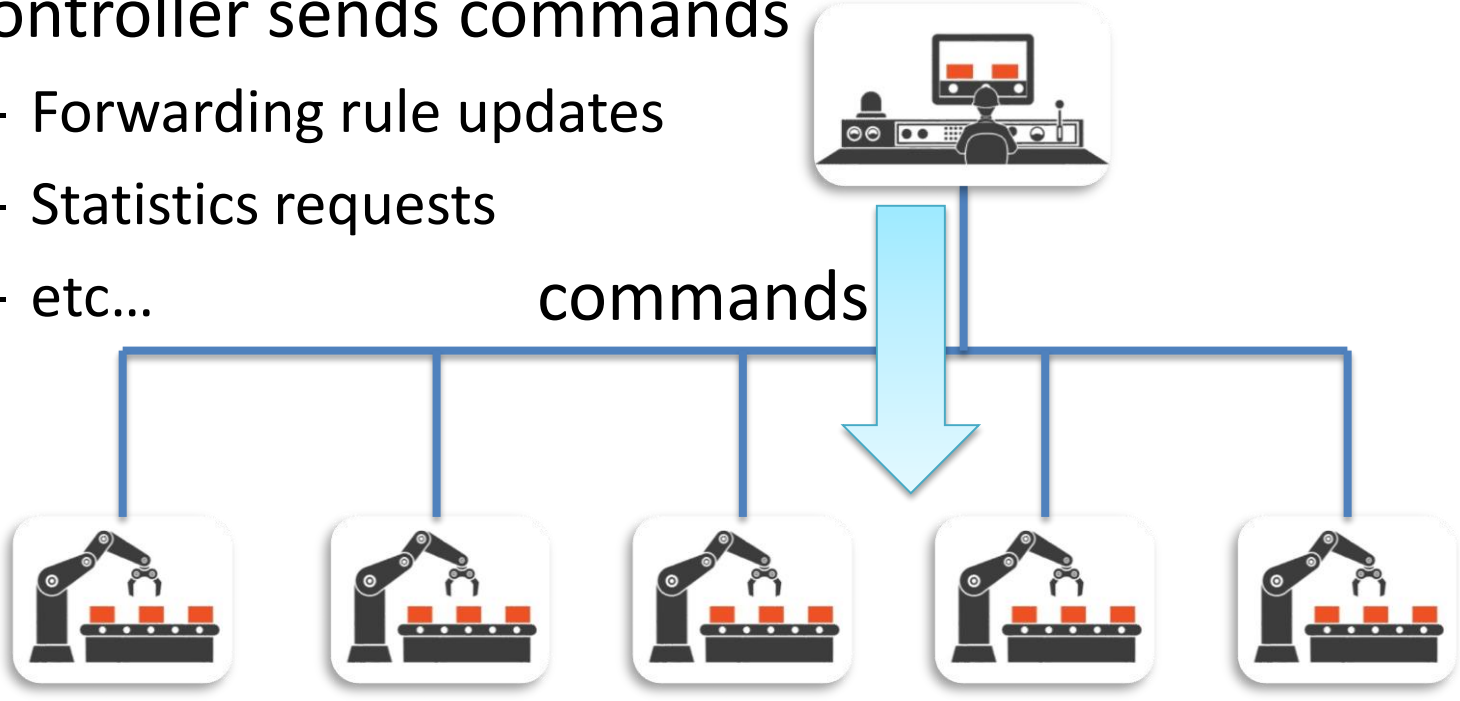
Software Defined Network (SDN)

- Events are sent to controller
  - Link failures
  - Unhandled packets
  - etc…



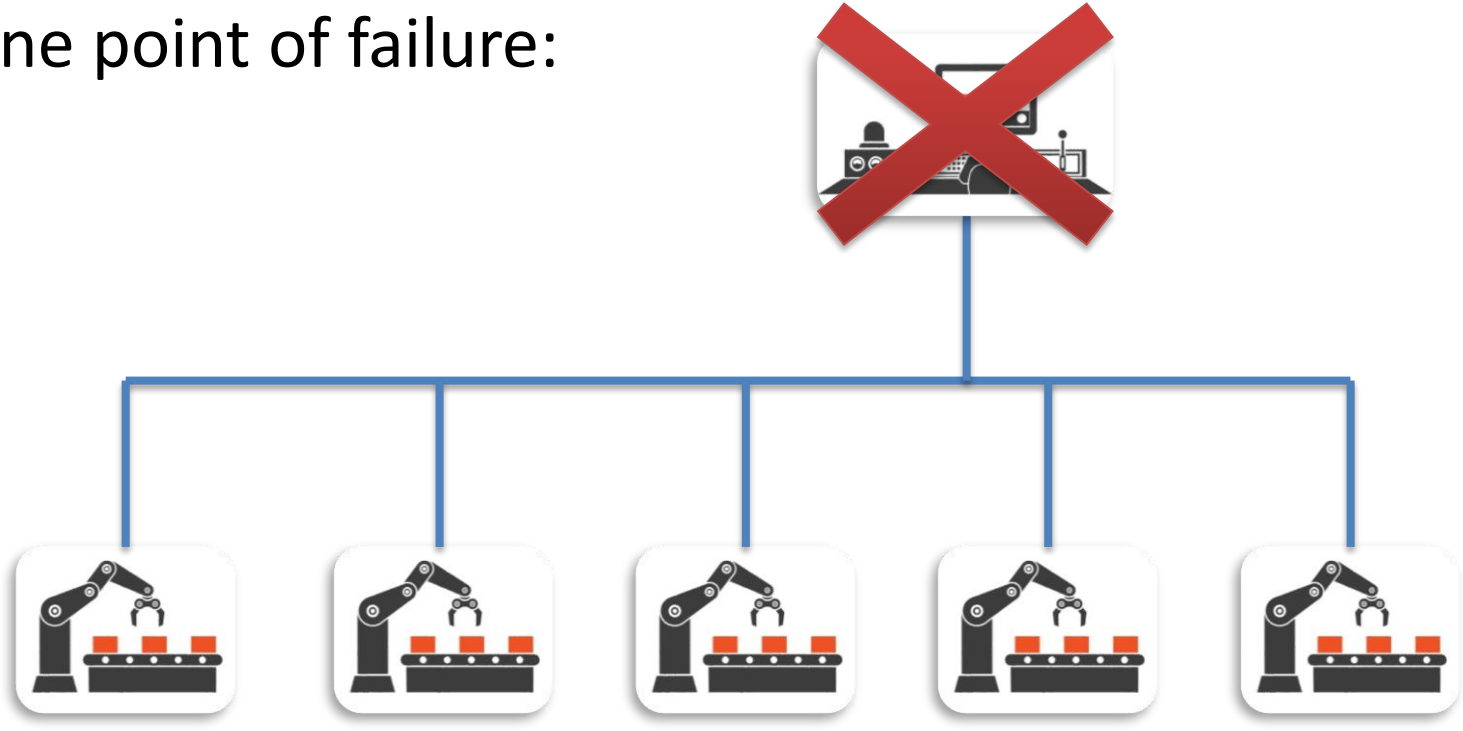
Software Defined Network (SDN)

- Controller sends commands
  - Forwarding rule updates
  - Statistics requests
  - etc…



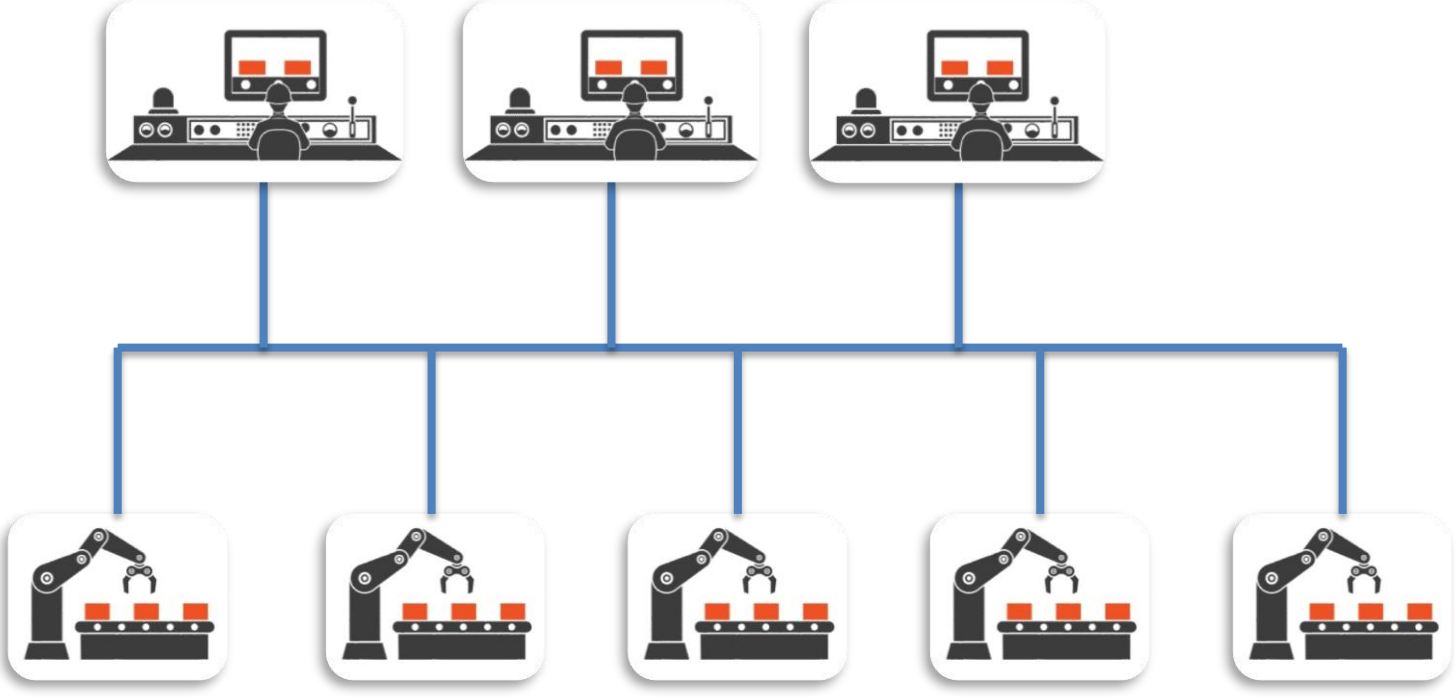
Software Defined Network (SDN)

- One point of failure:



Software Defined Network (SDN)

- Logically centralized, physically distributed

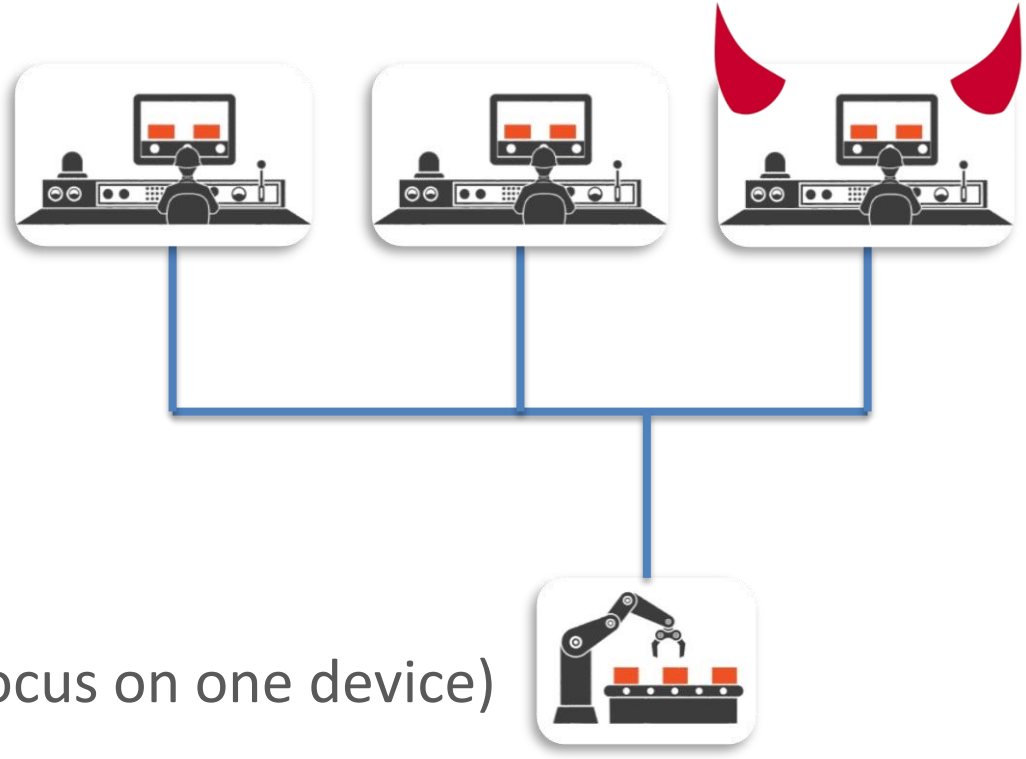


Distributed Control Security Issues

- The control network can be compromised
  - Advanced Persistent Threat (APT)
  - Insider
- Some controllers might be more vulnerable
  - Physical isolation
  - Logical isolation (policies)
  - Control applications
  - Admins
- We assume most controllers are secured

Distributed Control Security Issues

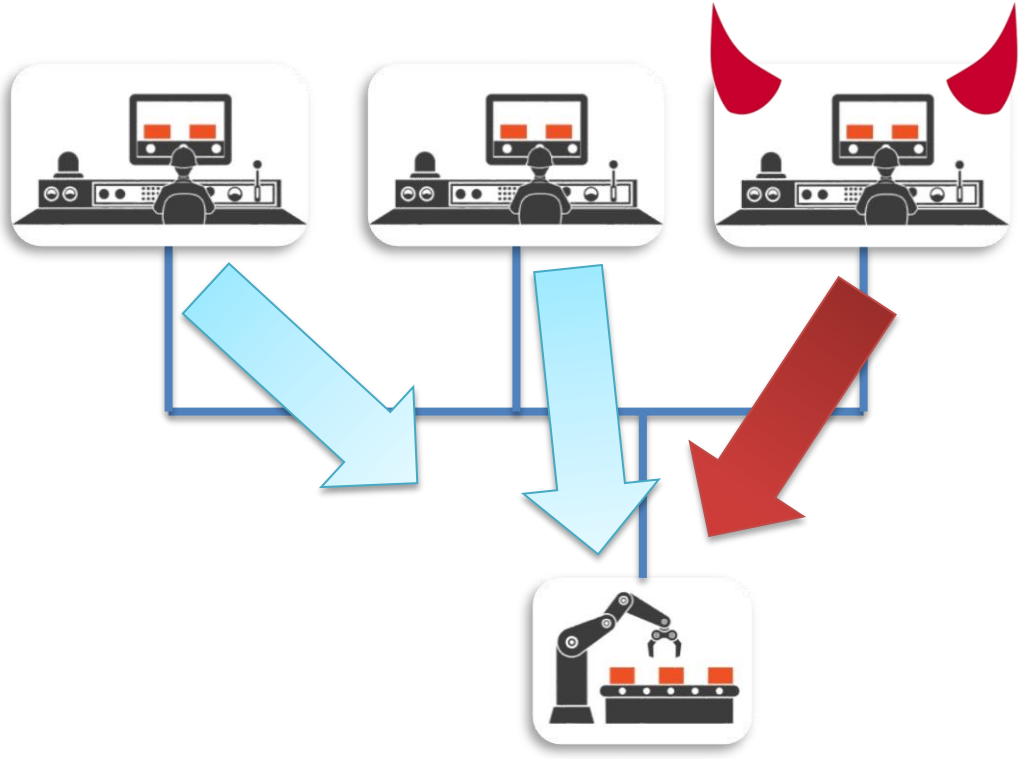
- A compromised control network:



- (we focus on one device)

Distributed Control Security Issues

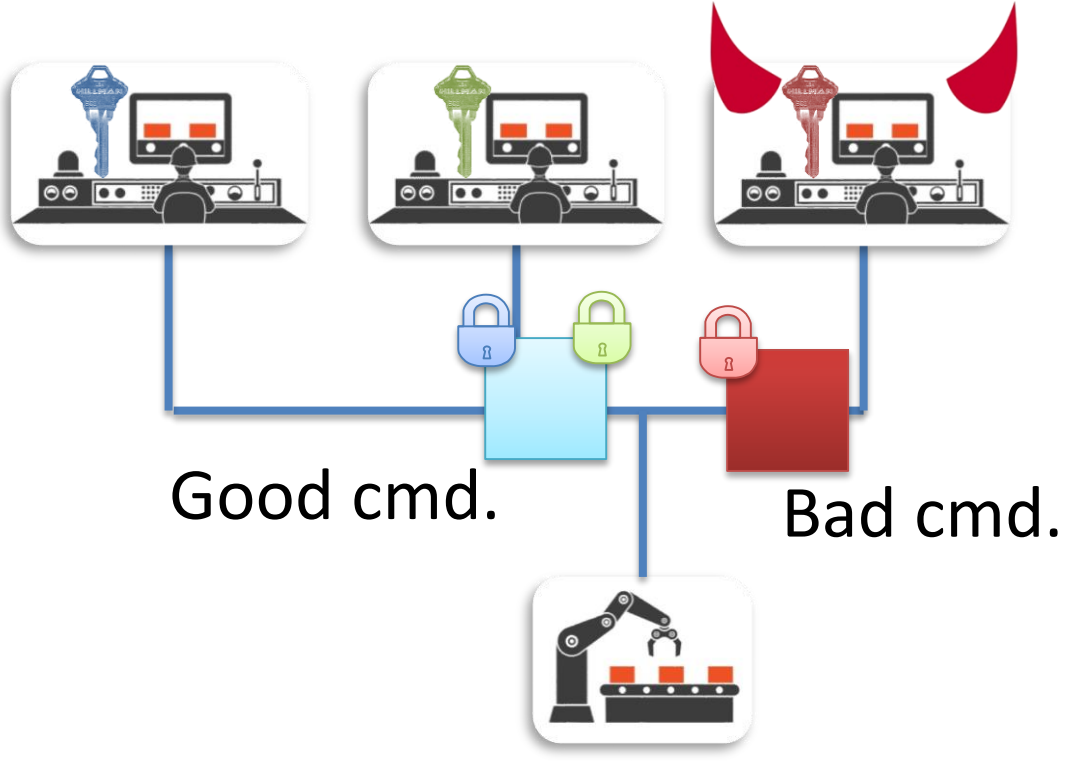
- Malicious commands attack



Distributed Control Security Issues

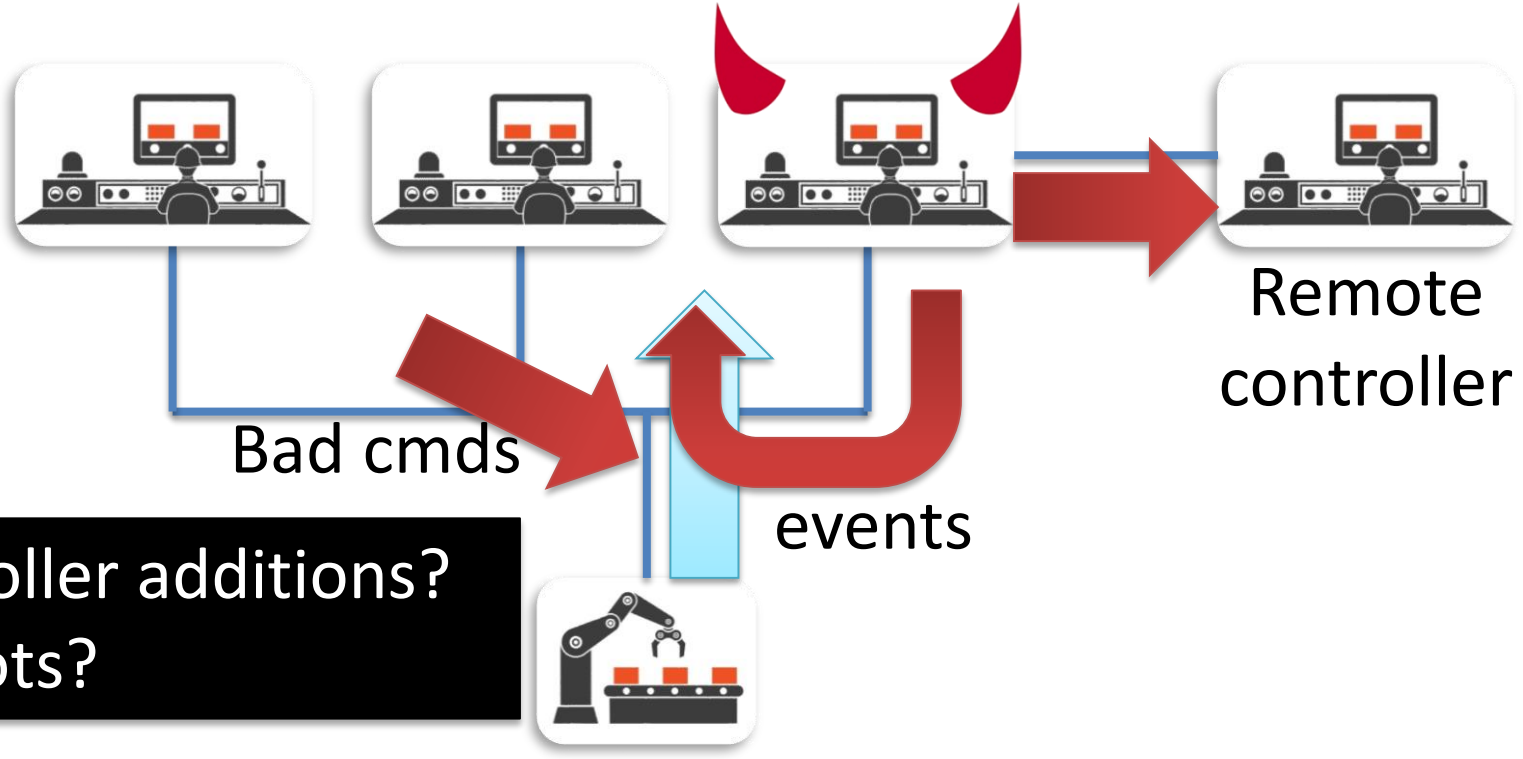
- Solution: Sign commands with threshold cryptography

  Fleet [S. Matsumoto , S. Hitz , A. Perrig 2014]



Distributed Control Security Issues

- Controller state corruption: deletion or injection of events



Controller additions?
Reboots?

Theoretical Approach

- Use a distributed shared log algorithm (e.g., Paxos)

- Each entity (device / controller):
  - Suggests log entry (event / command)
  - Considers previous entries
- Controllers can support other's suggestion
- Device performs commands supported by majority

Theoretical Approach

- Cons:
  - Most distributed shared log implementations are hard to verify [D. Ongaro J. Ousterhout 2014]
  - Limited support for failures / adversaries
  - Expensive design for devices

Our Approach

- Recognize the asymmetry
  - Device failure is inherently blocking
  - Device “knows” the correct input (event history)

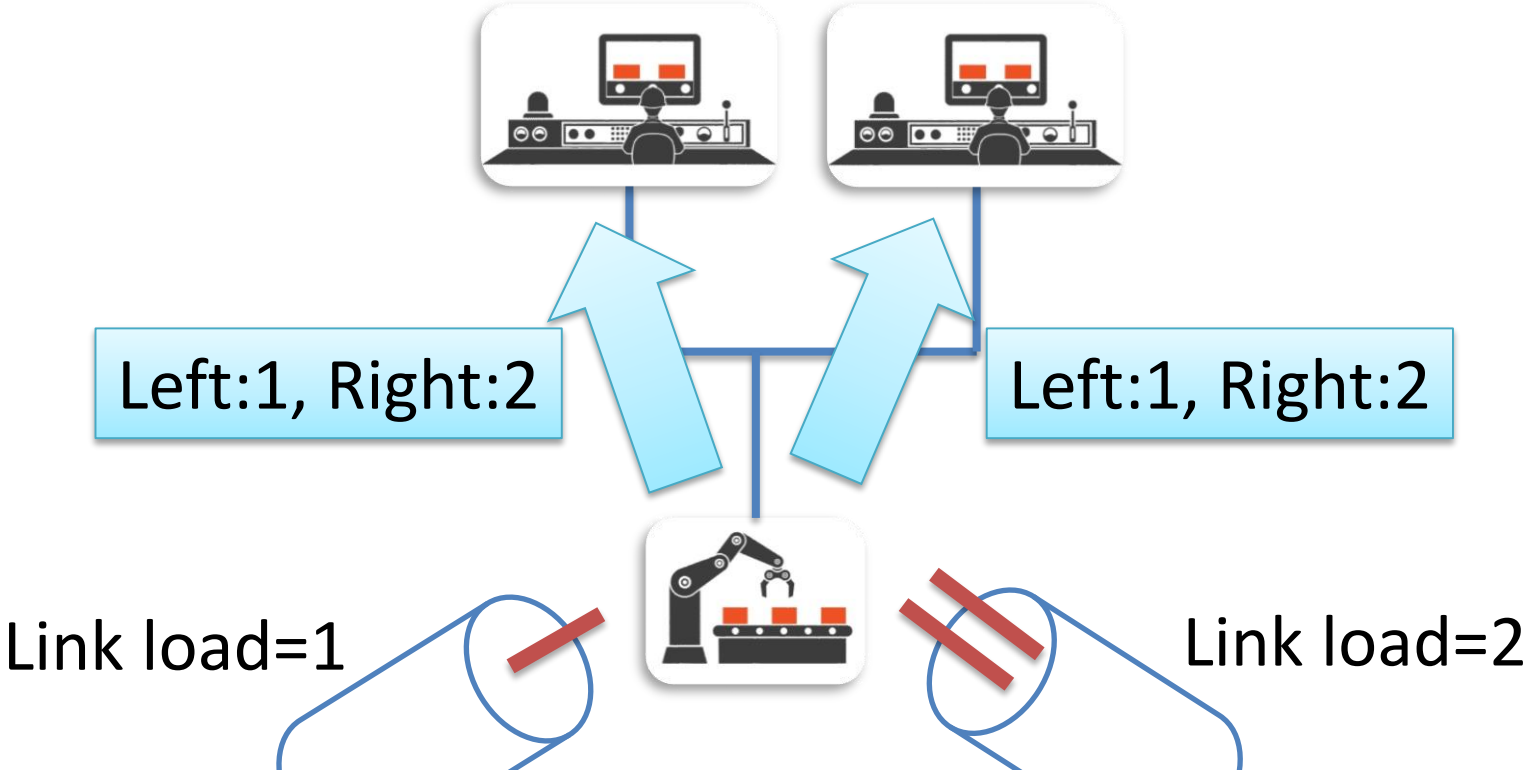
- Light adaptation to devices
  - Store the hash of all sent events/commands (history)
  - Accept command iff:
    - Contains correct hash
    - Signed (including the hash) by majority of controllers

Our Approach

- Other considerations:
  - Prevent race conditions (events vs. commands)
    - Keep a buffer of recent hash values
    - Accept commands with hash within buffer
  - Support fast initialization of new (or delayed) controllers
    - Commands includes controller state hash
    - New controller contacts “old” controller to receive state
    - Then contacts device to verify state

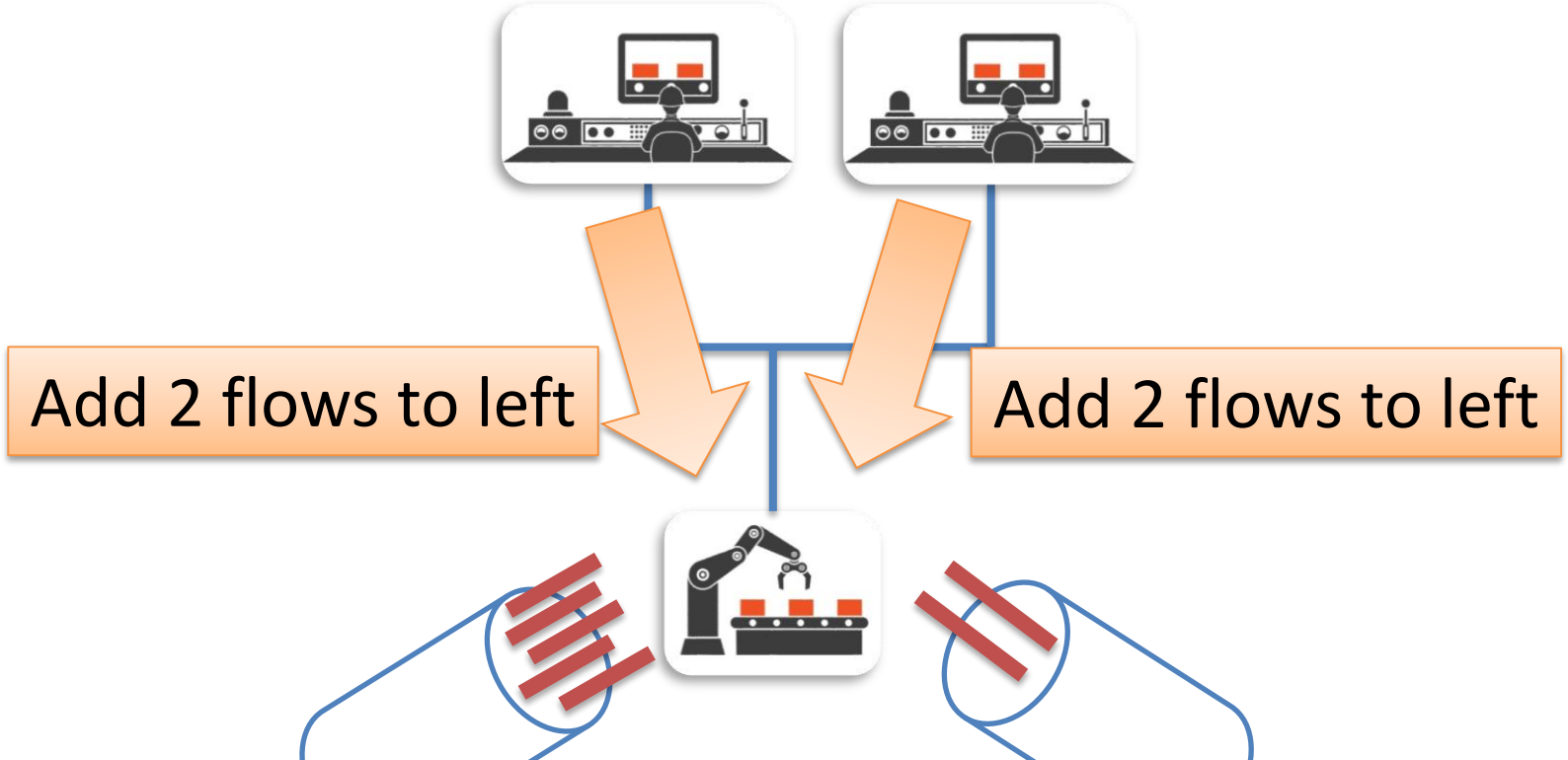
Similar Distributed Control Issue

- Concurrent configuration updates
- Example: load-balancing



Similar Distributed Control Issue

- Concurrent configuration updates
- Example: load-balancing



Our Approach [CCR16]

- Consider the centrality of the device
  - Device failure is inherently blocking
  - Device "knows" the current configuration

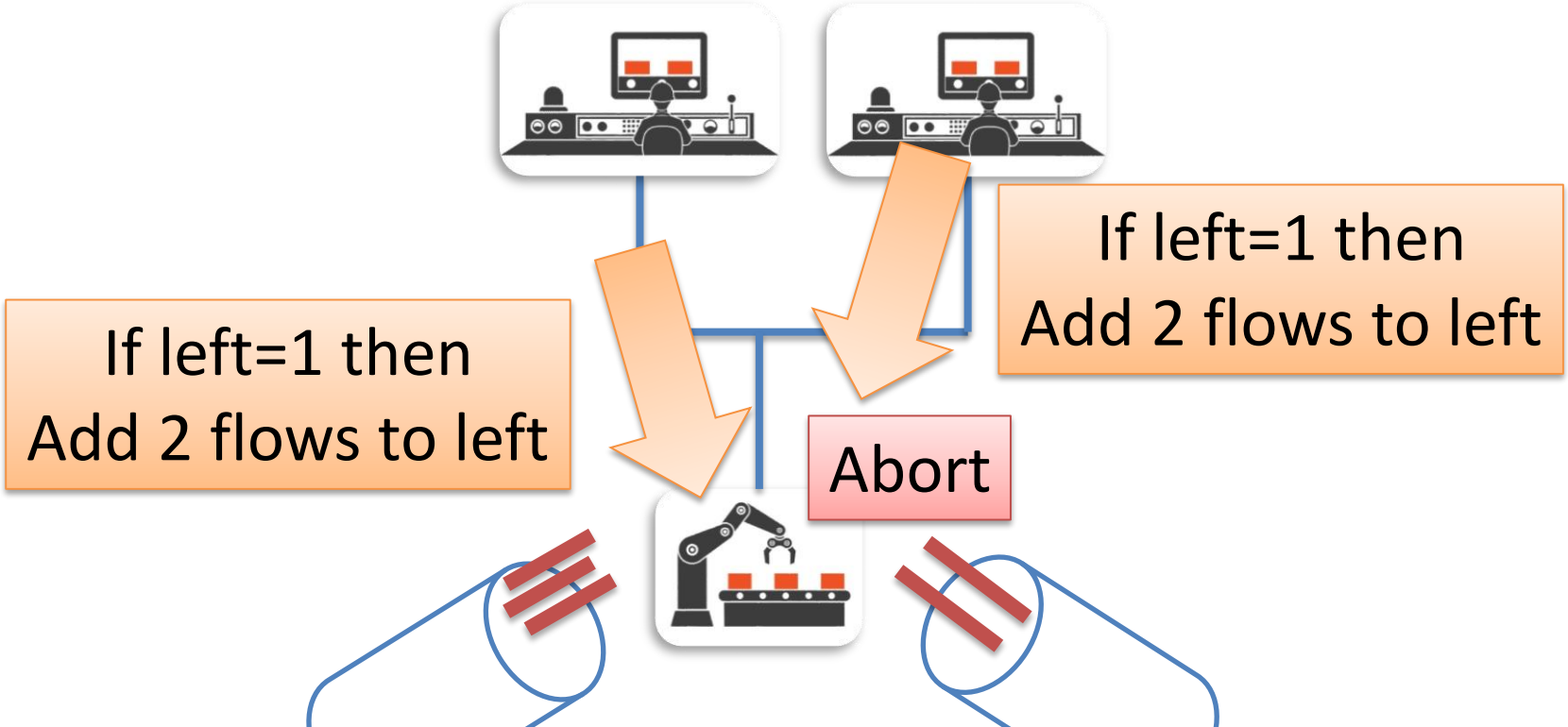
- Zero ~~Light~~ adaptation to devices
  - Implement conditional updates
  - Based on OpenFlow (v1.4)

- Transactions over switch configuration space!

L. Schiff, S. Schmid, P. Kuznetsov: **In-Band Synchronization for Distributed SDN Control Planes.** In ACM Computer Communication Review (CCR) 46(1): 37-43 (2016).

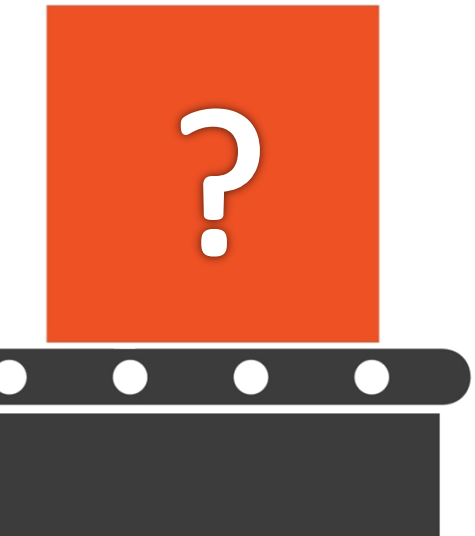
Our Approach [CCR16]

- Conditional updates



Summary

- SDN control plane might be compromised.
- Past events must be considered and verified.
- Our device centric approach provides a lightweight solution.
- Same approach can solve concurrency issues.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