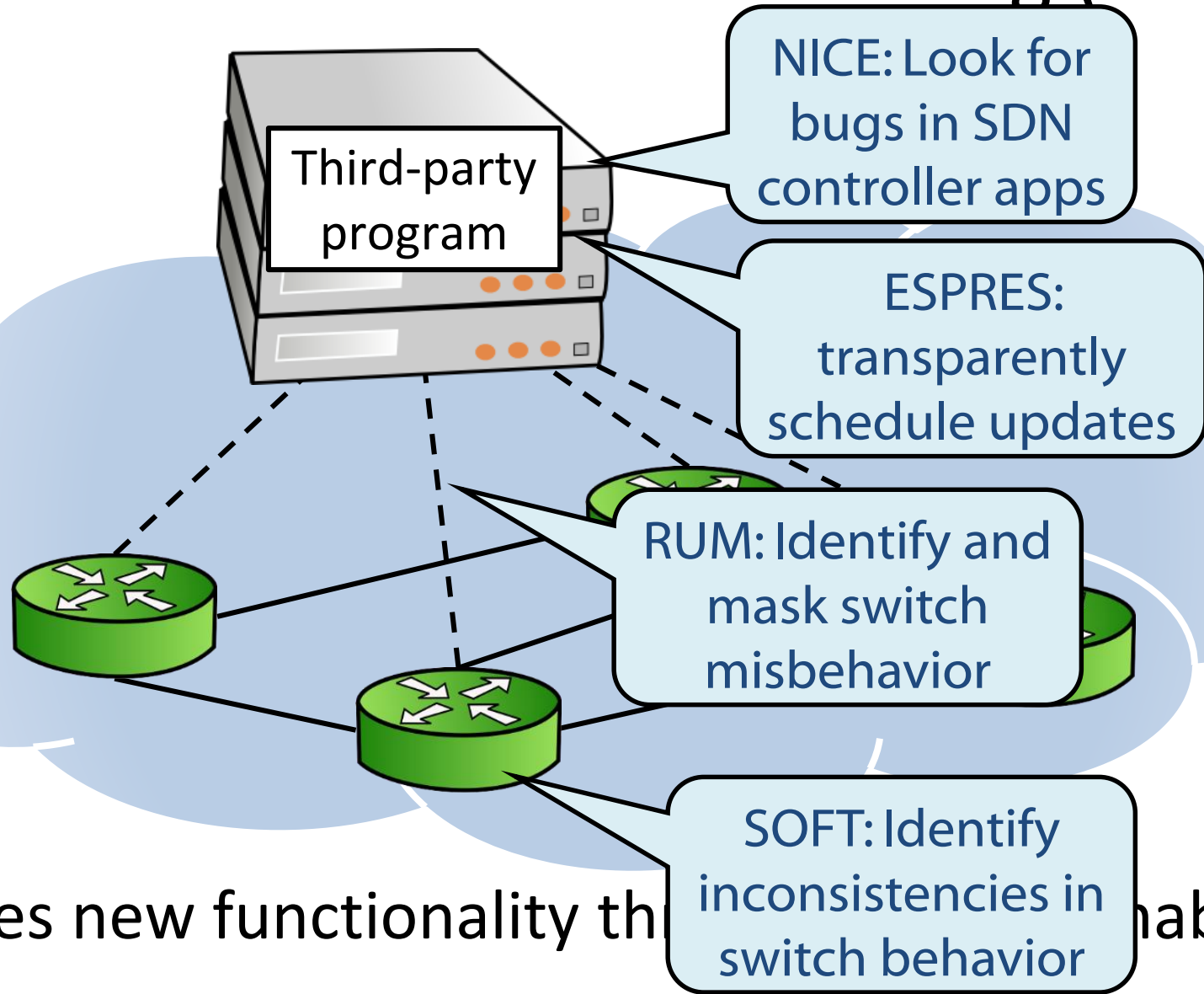




# Software-Defined Networking and Cloud Computing at the NSLab

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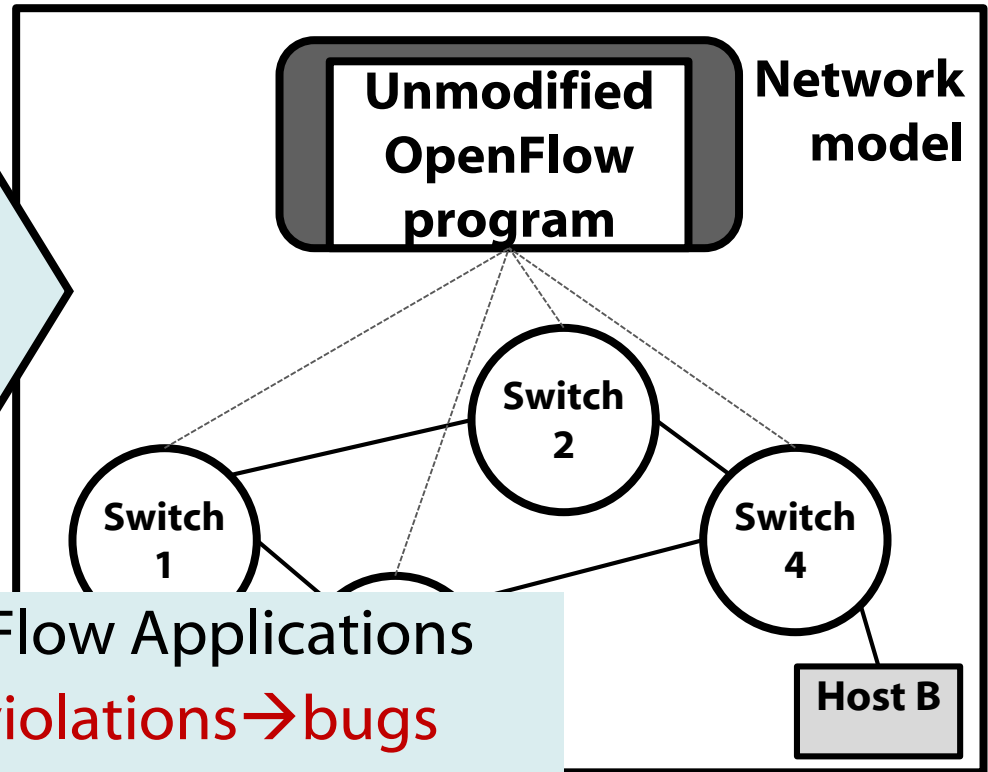
# Software-Defined Networking (SDN)



Enables new functionality that improves network stability ...

# NICE [NSDI '12]: *No bugs In OpenFlow Controller Execution*

1. Values of packet header fields
2. Orderings of packet arrivals and events

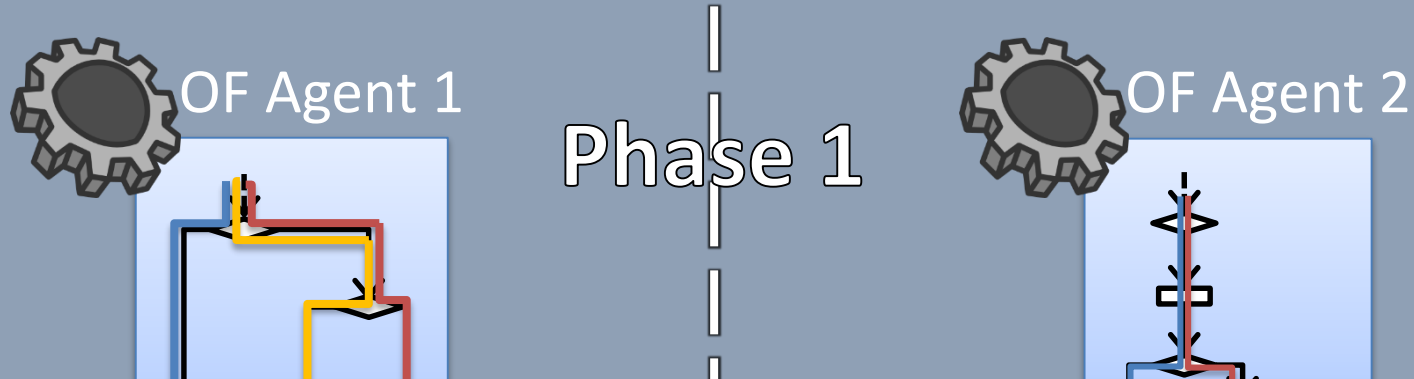


- Tested 3 **unmodified** OpenFlow Applications
  - NICE found 11 property violations → bugs
- Released as open-source
  - Downloaded 400+ times
  - Used at other Universities

ons using  
odel checking

# SOFT [CoNEXT '12] Overview

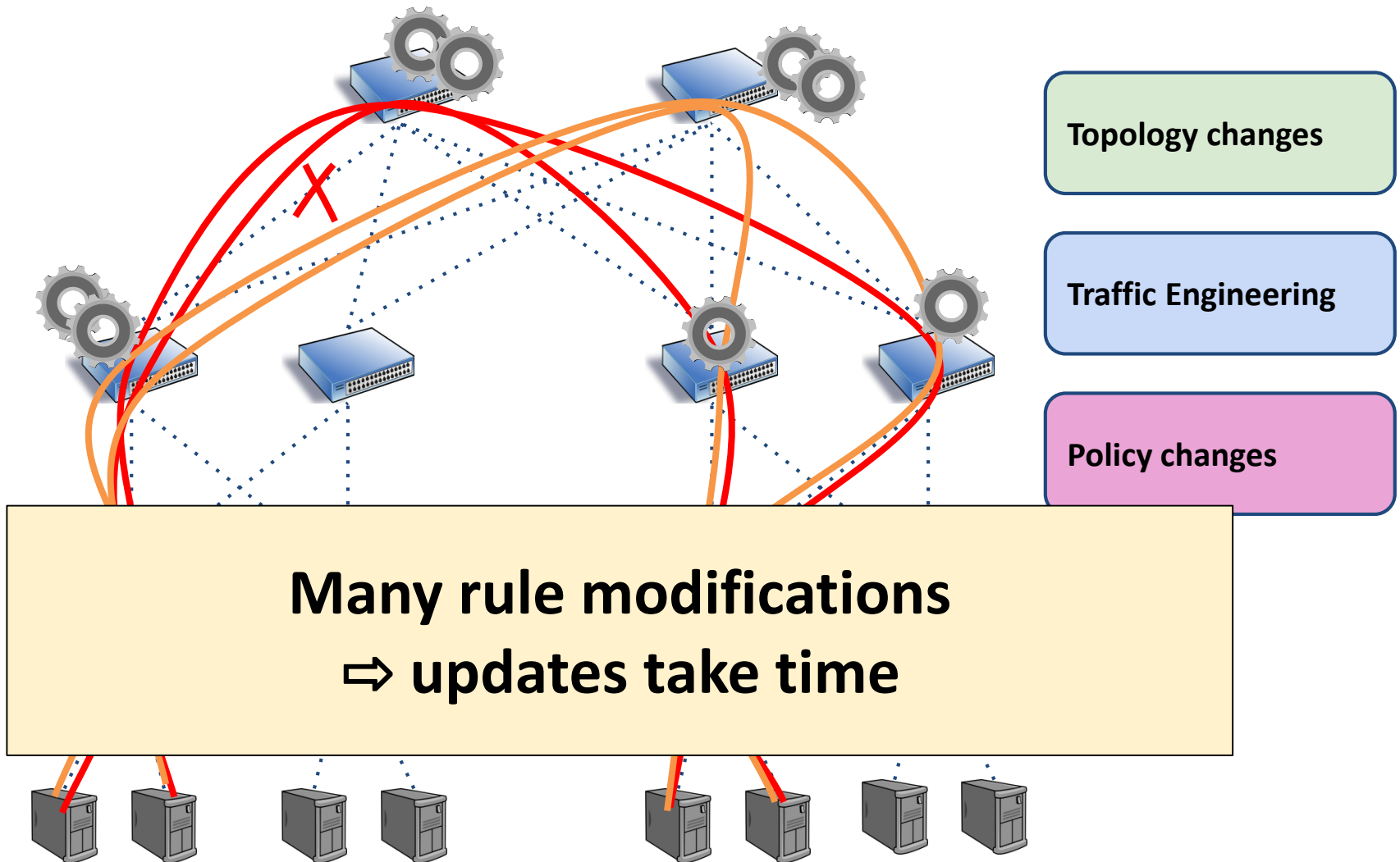
(Systematic OpenFlow Testing)



- Automated solution to interop testing
- Systematic code coverage
- No simultaneous access to all agents

~~Phase 2~~

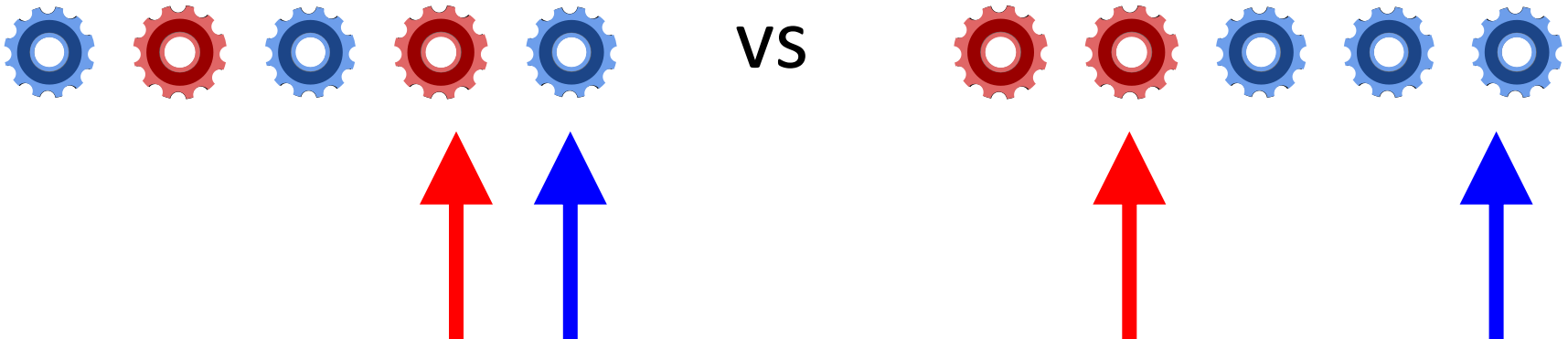
# Network events trigger big updates



# What if we reorder installations...

Update touching two (independent) flows

- **total time same**
- **but**  
different **ordering** of rule installation **matters**

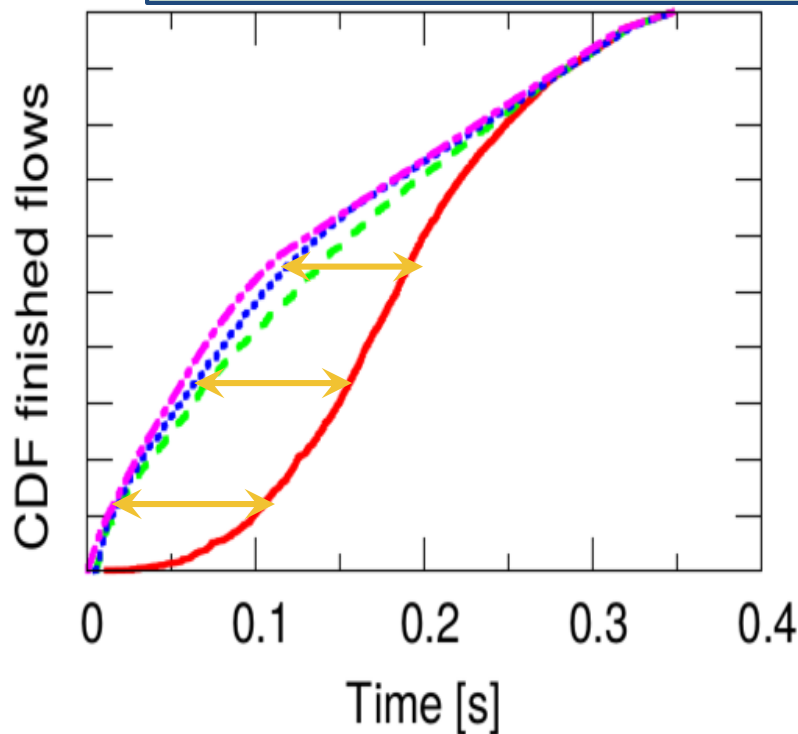


# ESPRES overview

- **Keep backlog of rule installations** in ESPRES
  - enables re-ordering on control channel
- **Schedule** rules to be installed next
  - **react on-the-fly** to current switch conditions
  - needs to be fast
  - support **flexible goals**

# A taste of results

We reduce completion time by  $\geq 40\%$  for half of flows



➤ No scheduling (send rule when dependencies are met)

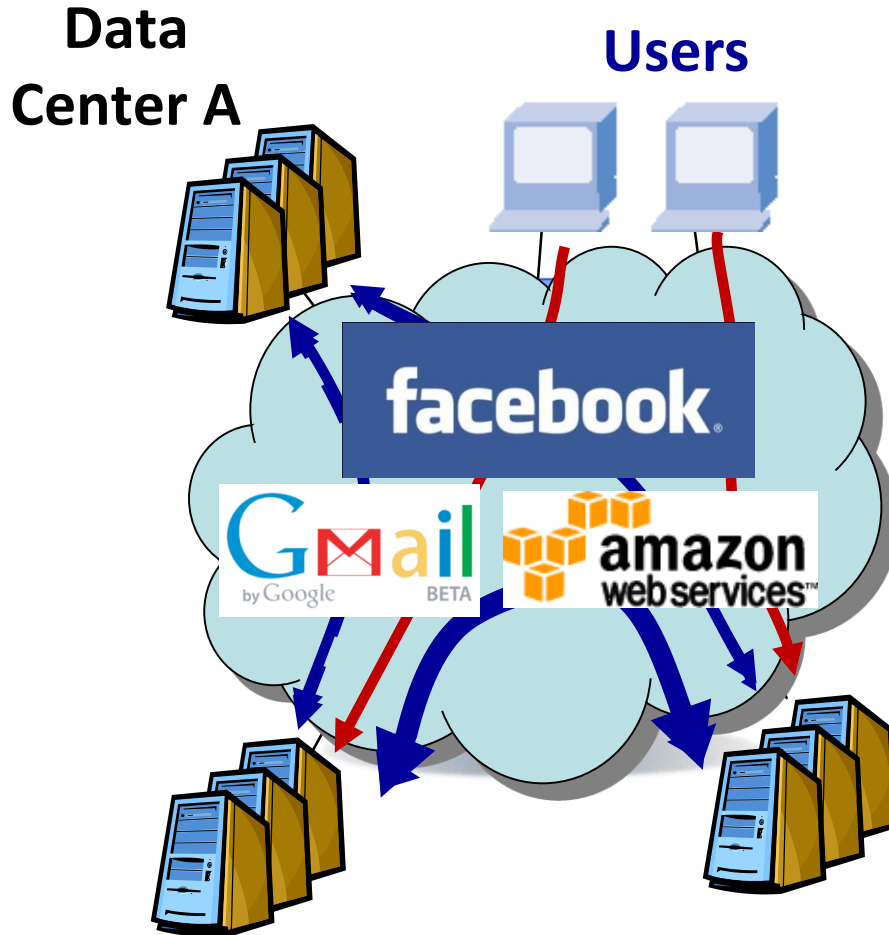
➤ Espres A

➤ Espres B

➤ Optimal (Offline)

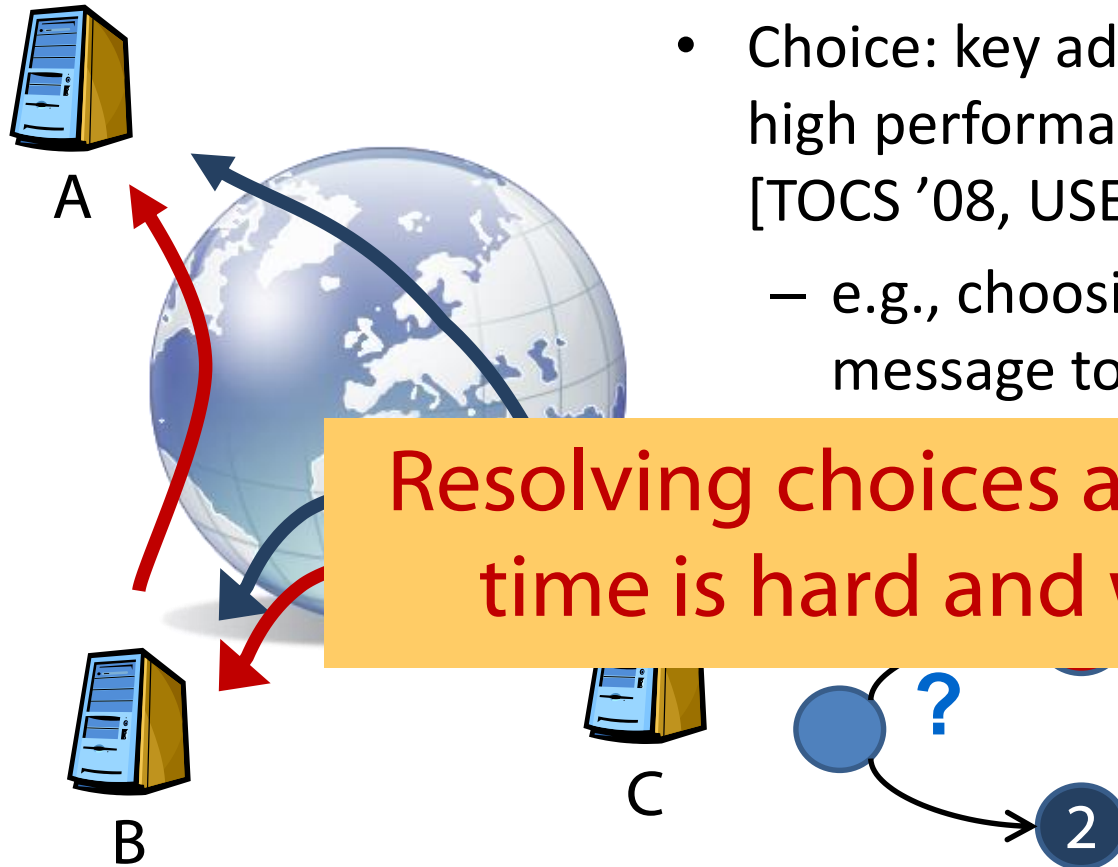


# Additional Challenge: Cloud Computing



- Dictates new objectives
  - 100% reliability
    - Not there yet: Facebook, Amazon S3, Gmail outages
  - High consistency, high throughput, and low latency
    - Hard to achieve over changing network conditions

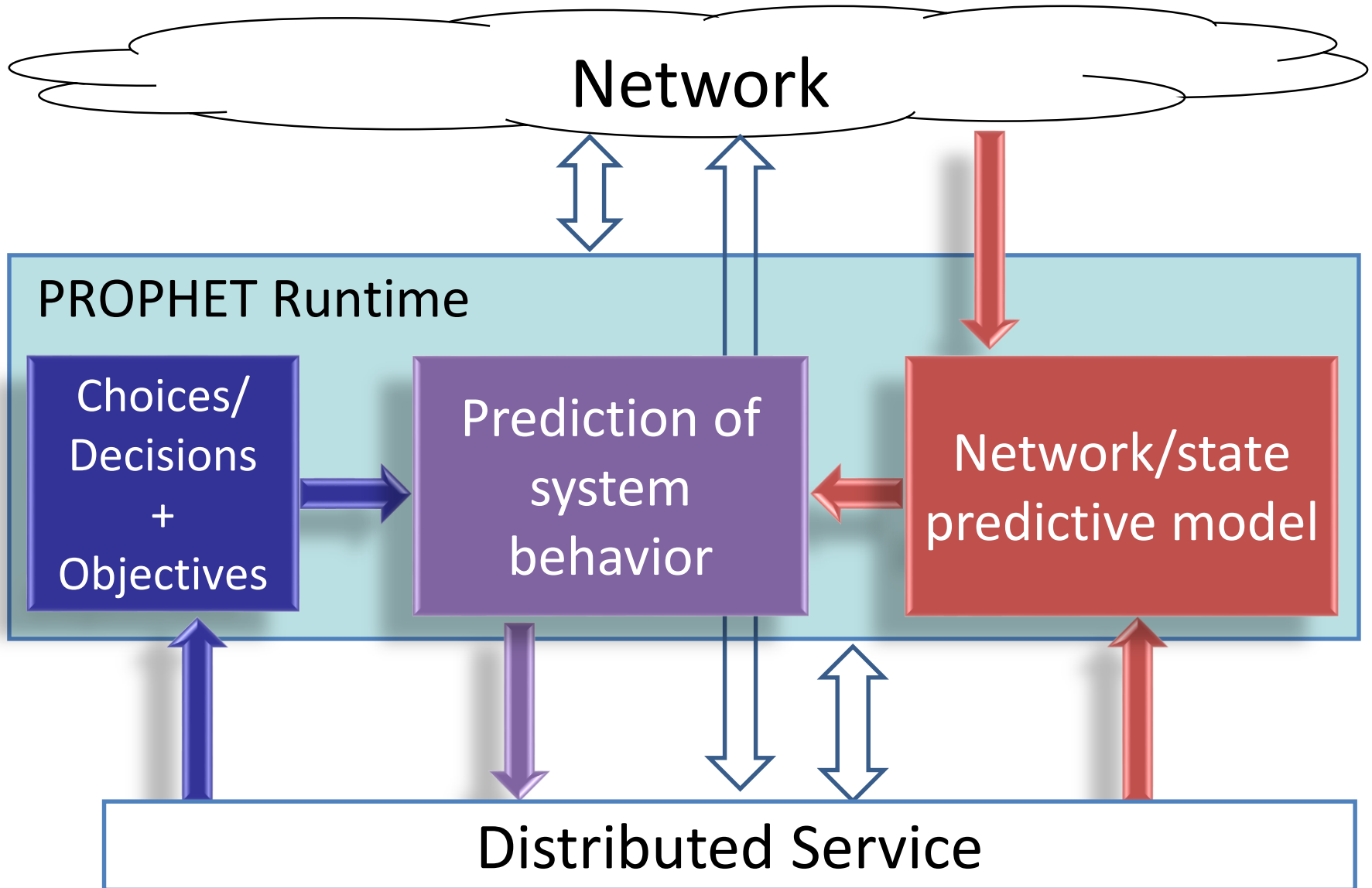
# High Performance Services Require Choice



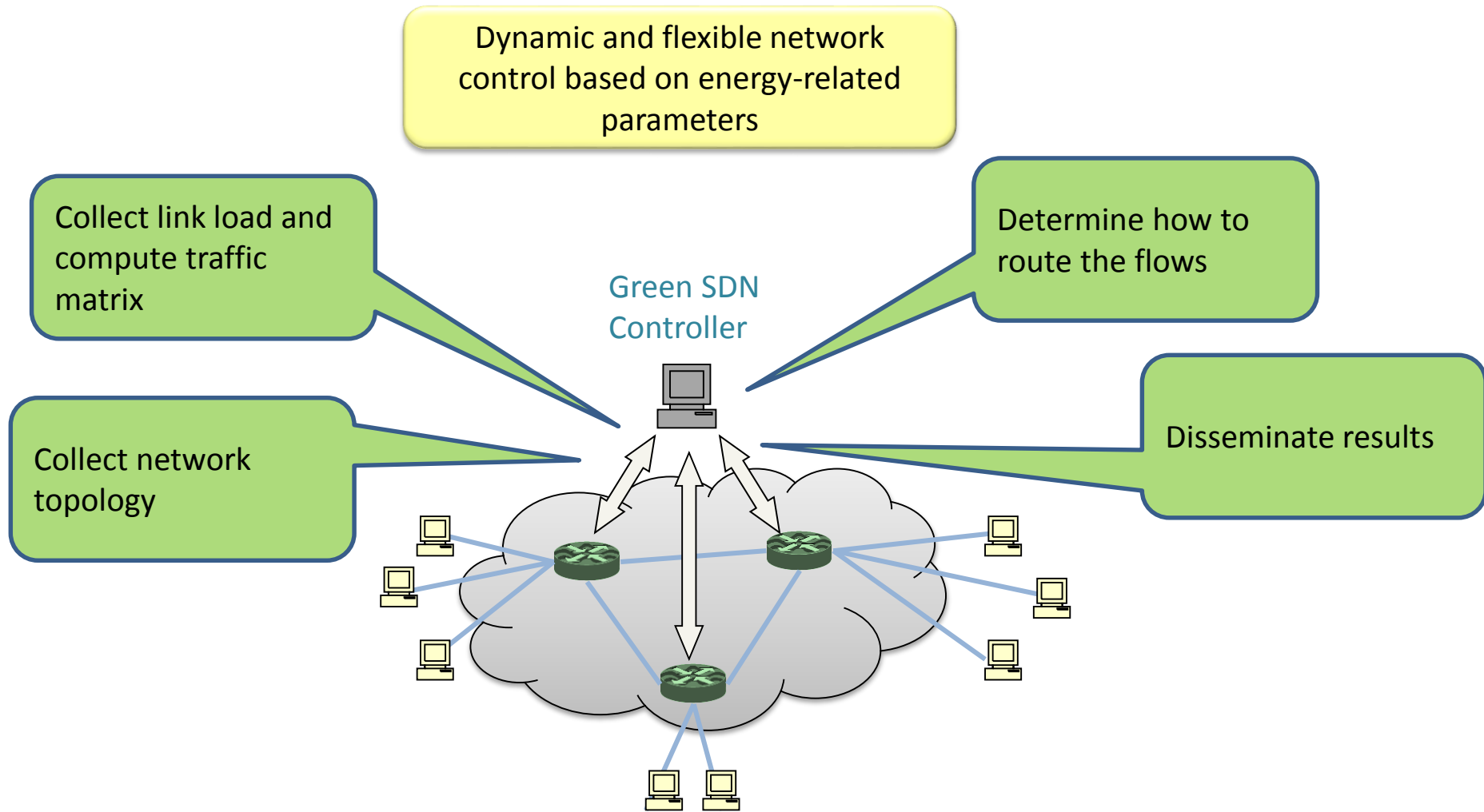
- Choice: key adaptation strategy for high performance  
[TOCS '08, USENIX '05, SOSP '03]
  - e.g., choosing node to send a message to

**Resolving choices at development time is hard and wastes effort**

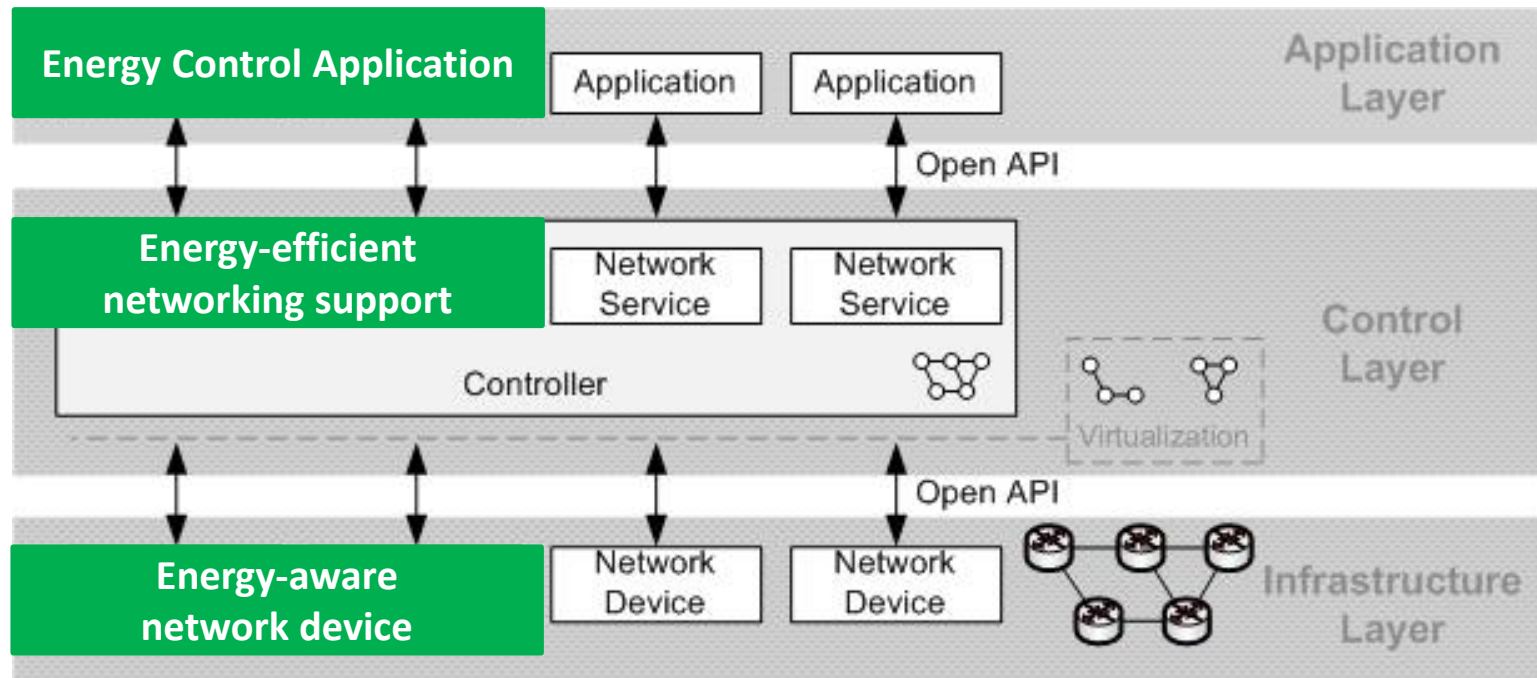
# Explicit-Choice Architecture



# SDN and Green Networking

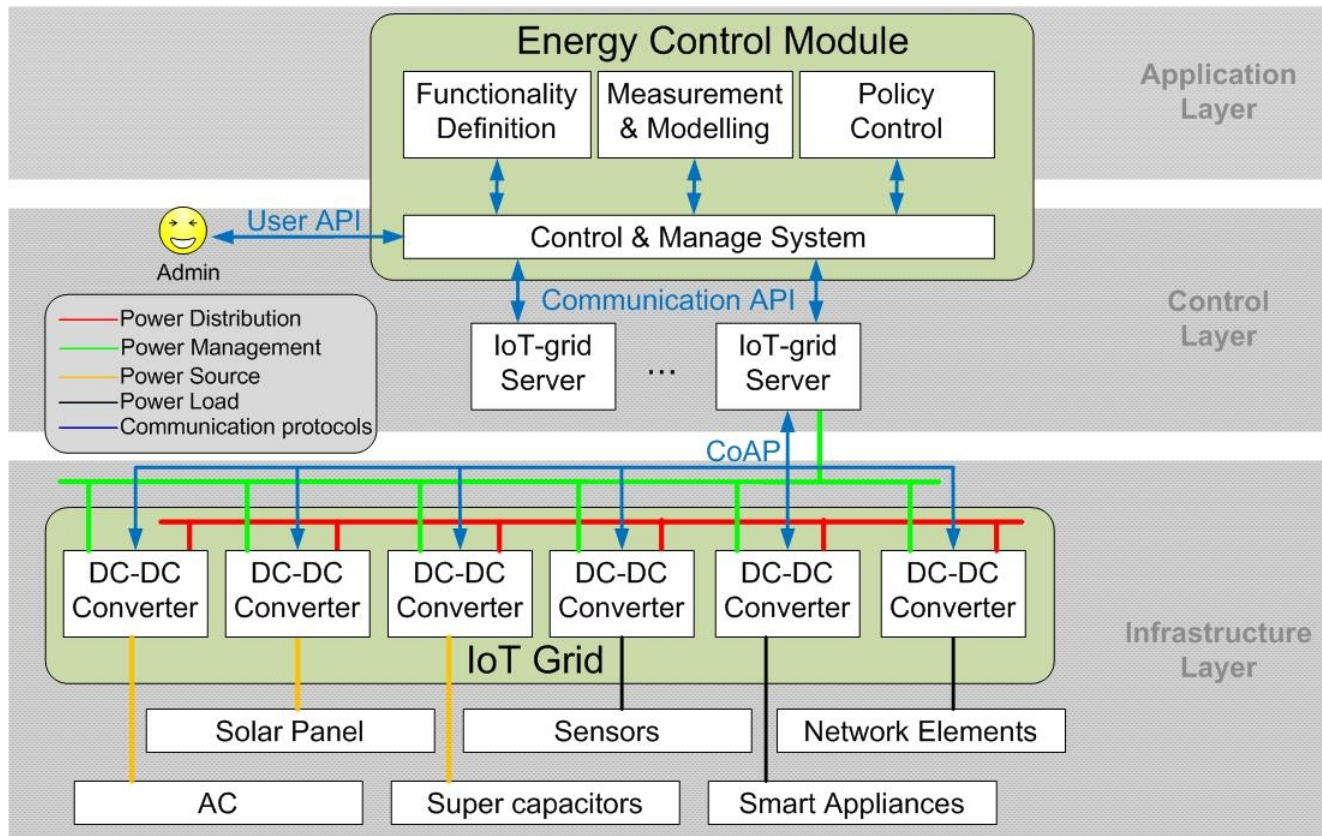


# SDN and Energy-awareness



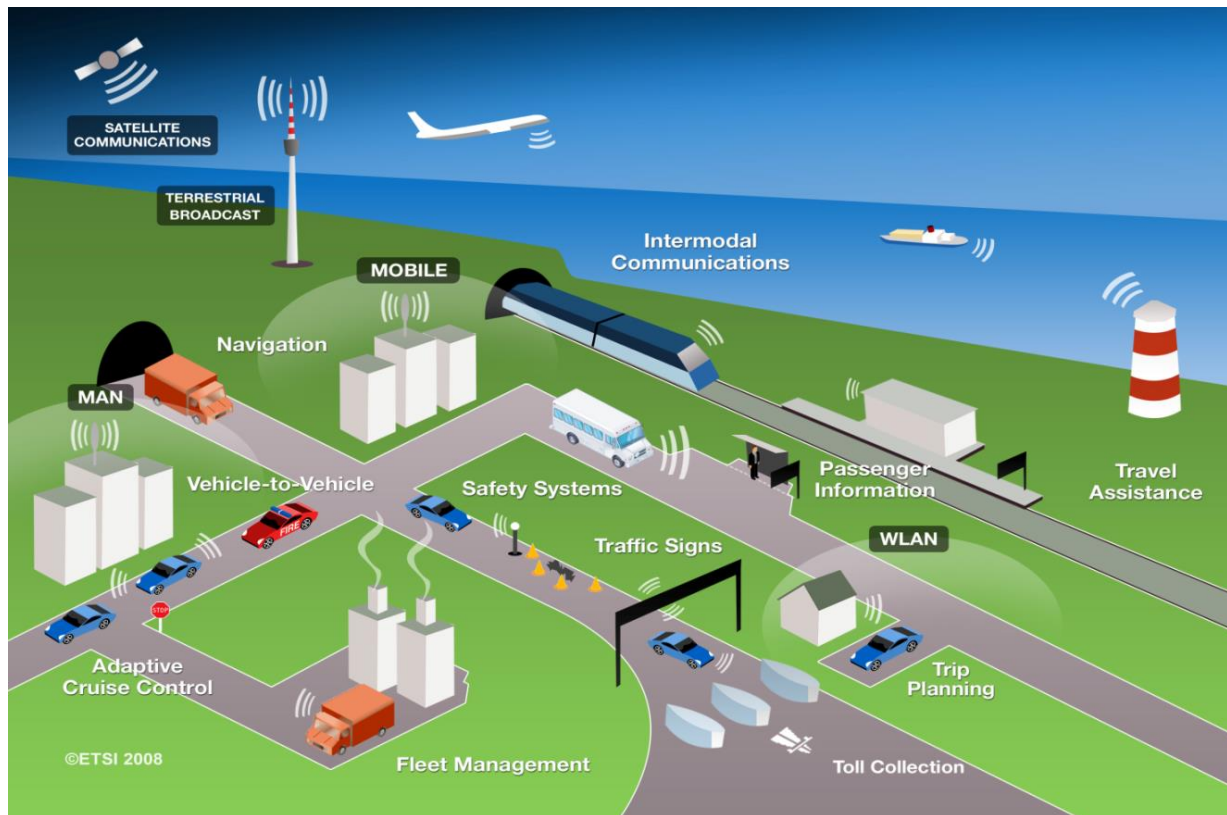
# IoT Grid—for Energy-smart Networks

IoT grid runs Contiki with communication support for remote power monitoring and control



# GreenIoT Project

Energy-efficient Internet-of-Things for air pollution monitoring and traffic planning



# Possible collaborations for KTH

- Teaming up to obtain funding and participate in GENI and distributed data center initiative
- Run ESPRES on large GENI network updates
- Debug GENI SDN controller apps
- Check switch interoperability
- Evaluate PROPHET's geo-distributed storage