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An OpenFlow Extension for the OMNeT++ INET Framework

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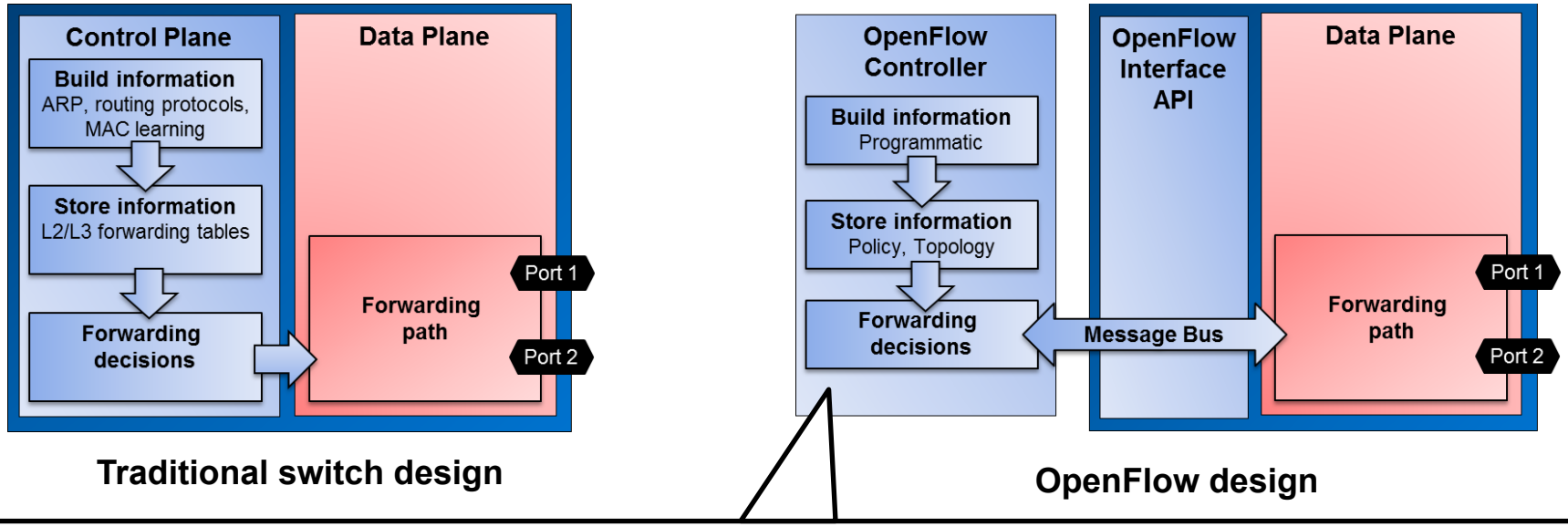
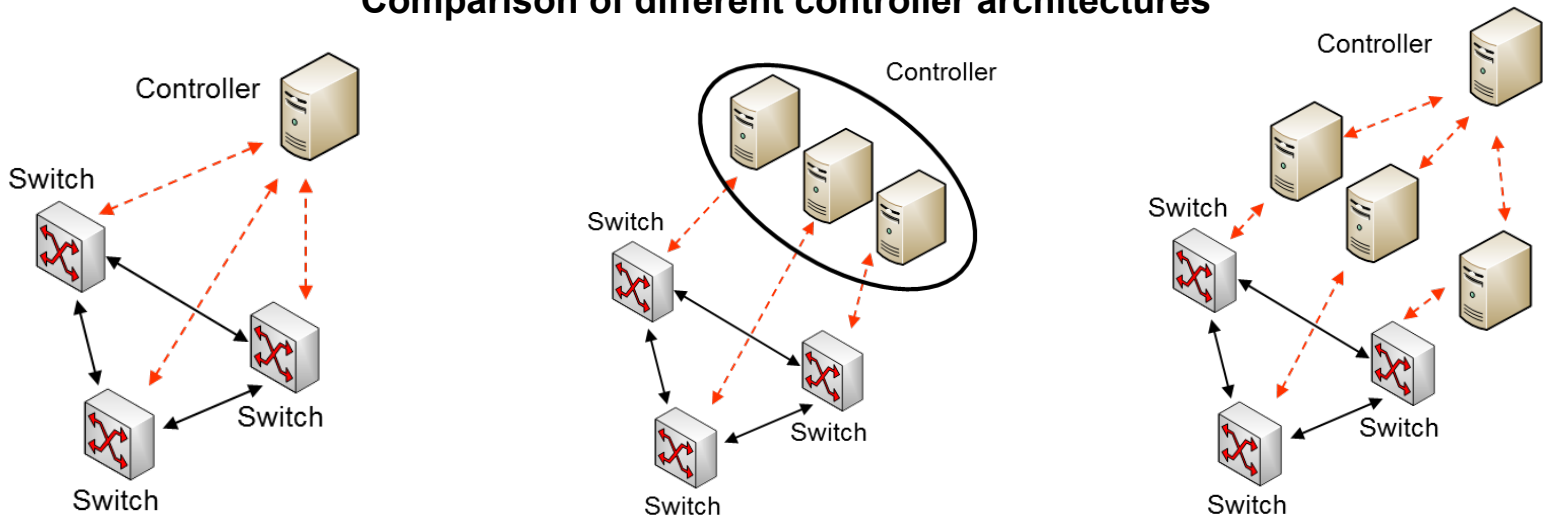
Motivation



Comparison of different controller architectures



Outline

- OpenFlow background
  - Basic principle and communication example
- OpenFlow simulation model
  - Implemented nodes and messages
- Proof-of-concept evaluation
  - Controller placement
- Summary and future work

OpenFlow Overview

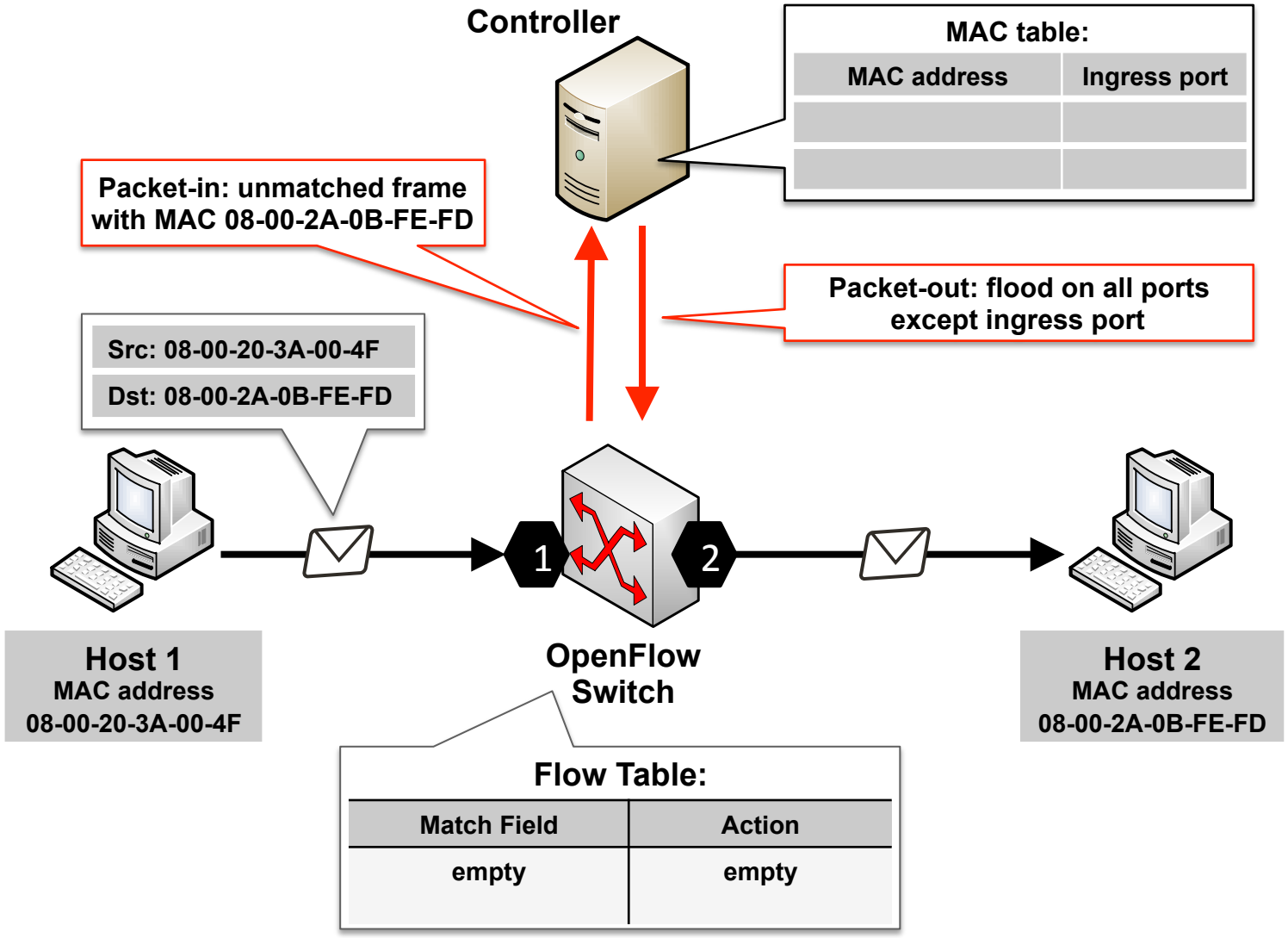
- Basic principle
  - Separation of control- and data-plane
  - Open standard
  - Added as feature to commercial switches

- OpenFlow specifies a communication protocol between the data plane of a networking element and a remote control plane

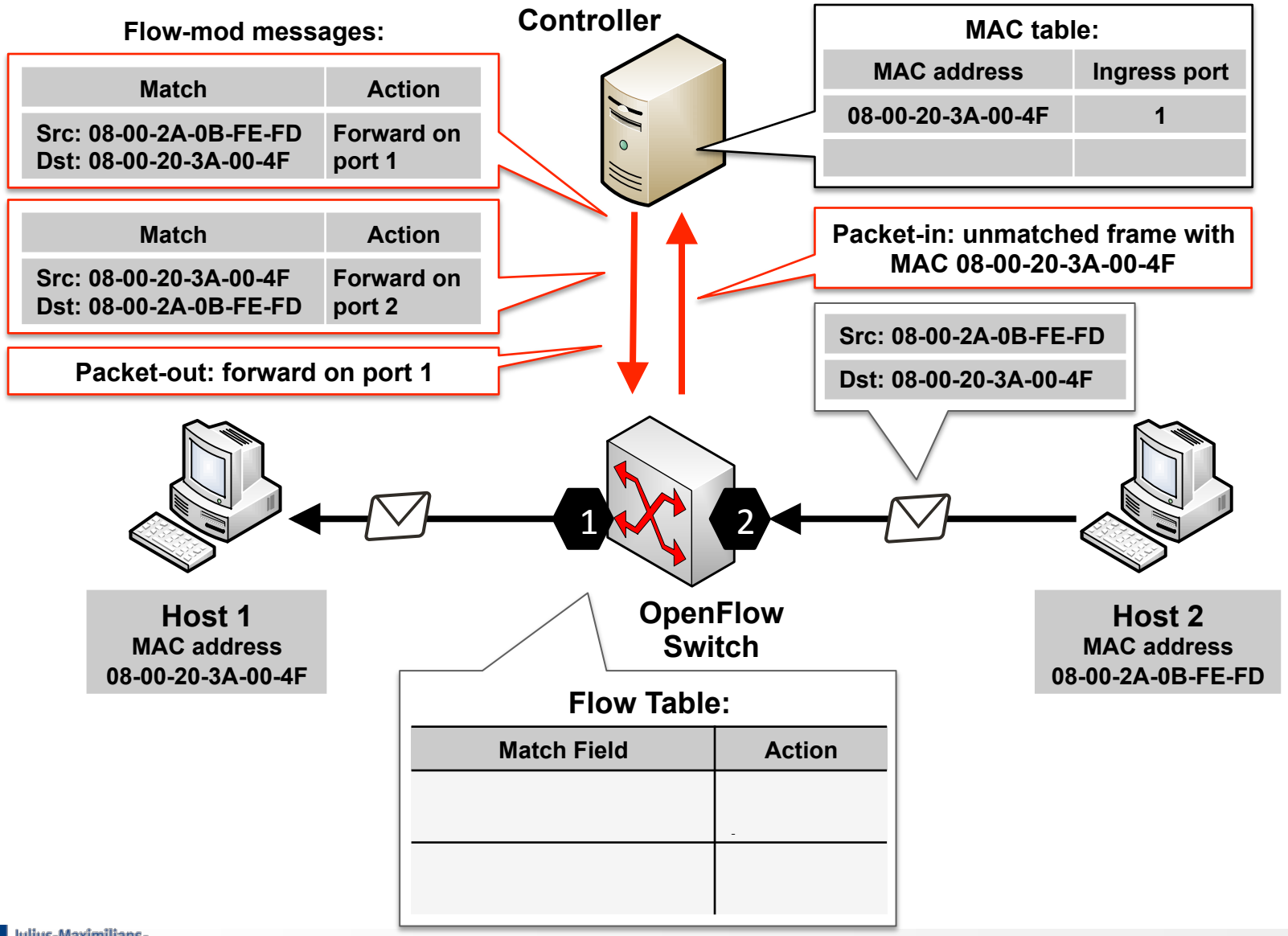
- OpenFlow introduced by the McKeown group at Stanford University (2008)

- Since version 1.2 the standardization body for OpenFlow is the Open Networking Foundation (ONF)

Communication in OpenFlow Network



Communication in OpenFlow Network



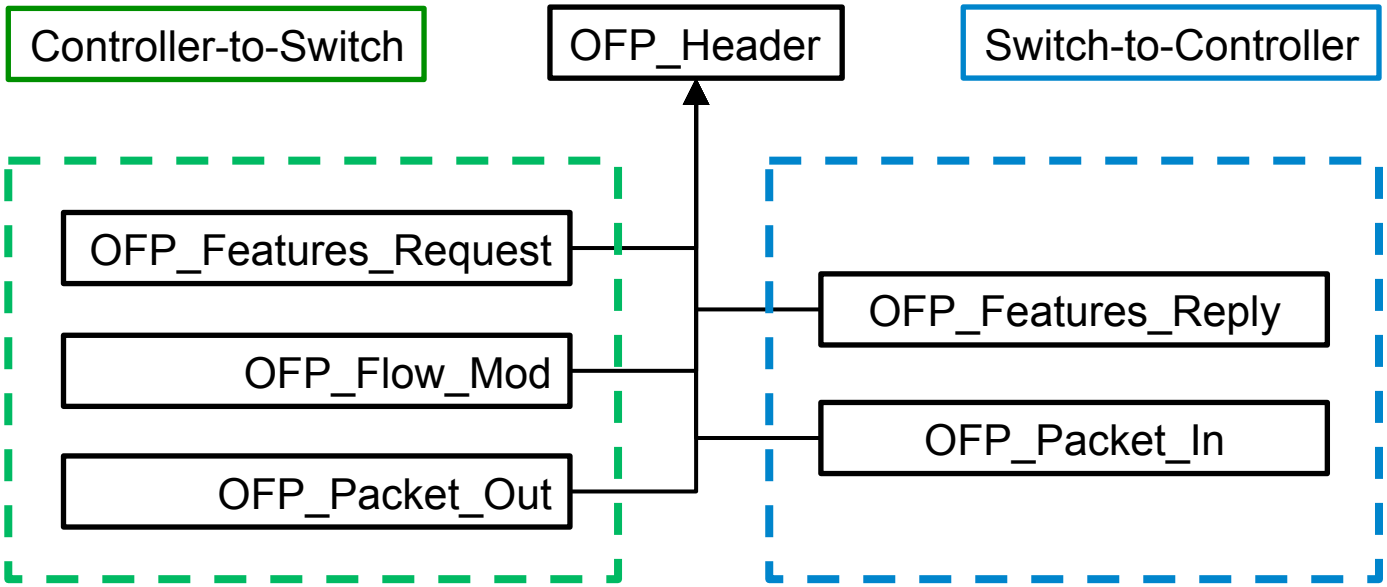
Overview Simulation Model

- Implementation background
  - Extends and requires INET framework version 2.0
  - **Implementation according to OpenFlow specification 1.0**
  - Based on OpenFlow header file

- Missing most important features of higher protocol versions
  - OpenFlow version 1.1
    - Multiple flow tables
    - Group actions
  - OpenFlow version 1.2
    - Extensible match support
  - OpenFlow version 1.3
    - Per flow meters

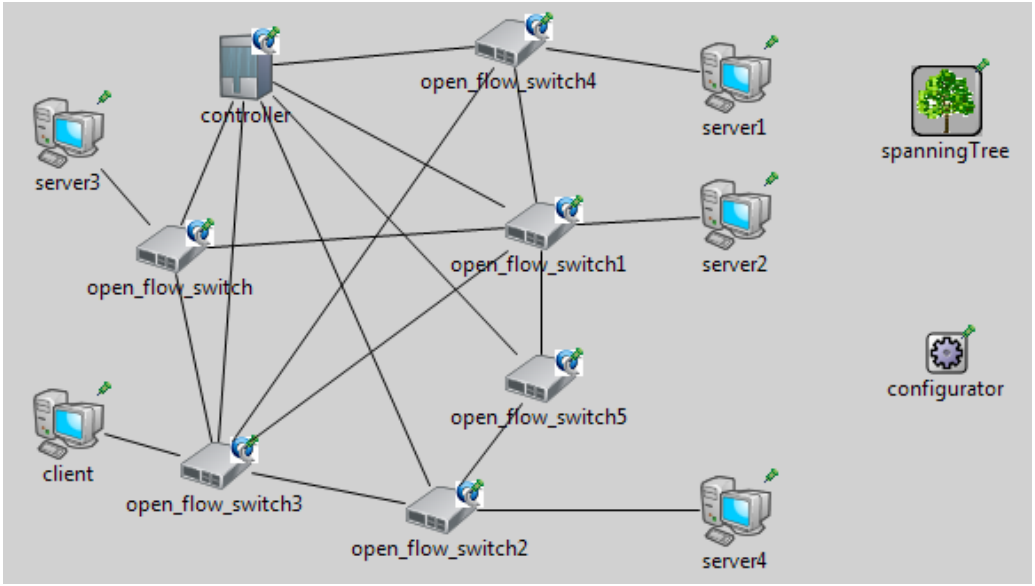
Implemented Messages

- Message types and message formats implemented according to OpenFlow specification
  - Establishment of OpenFlow channel
  - Asynchronous messages
  - Modify-state and packet-out messages

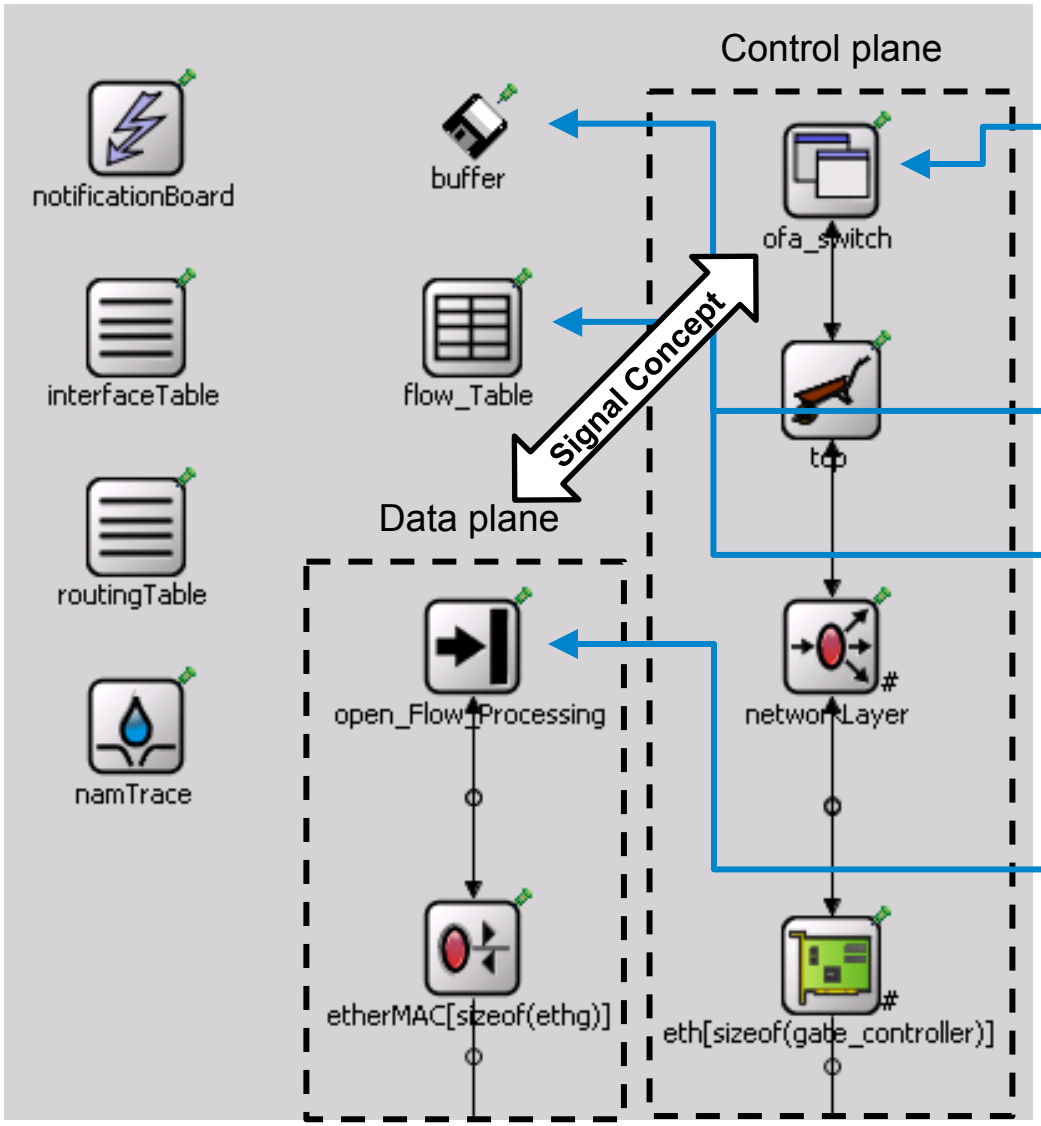


Implemented OpenFlow Nodes

- OpenFlow nodes
  - OpenFlow switch
  - OpenFlow controller
- Utility modules
  - Spanning tree module



OpenFlow Switch



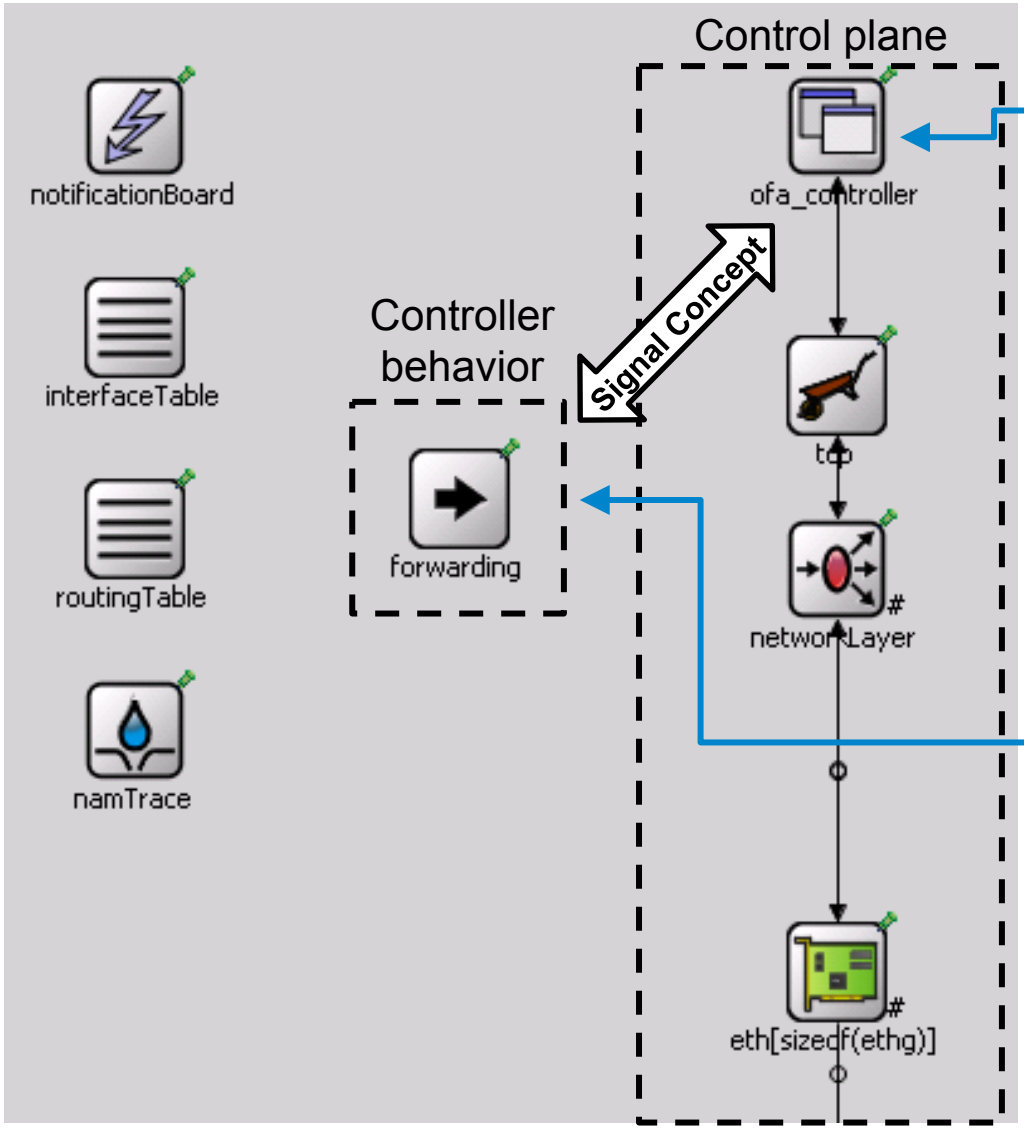
- Communication with controller
- Handling of unmatched packets (Packet-In message to controller)
- Handling of controller-to-switch messages

- Store messages during controller request

- Management of flow entries

- Message processing on data plane
- Perform flow table lookups
- Notify switch application module about unmatched packets
- Store packets in buffer during controller request

OpenFlow Controller

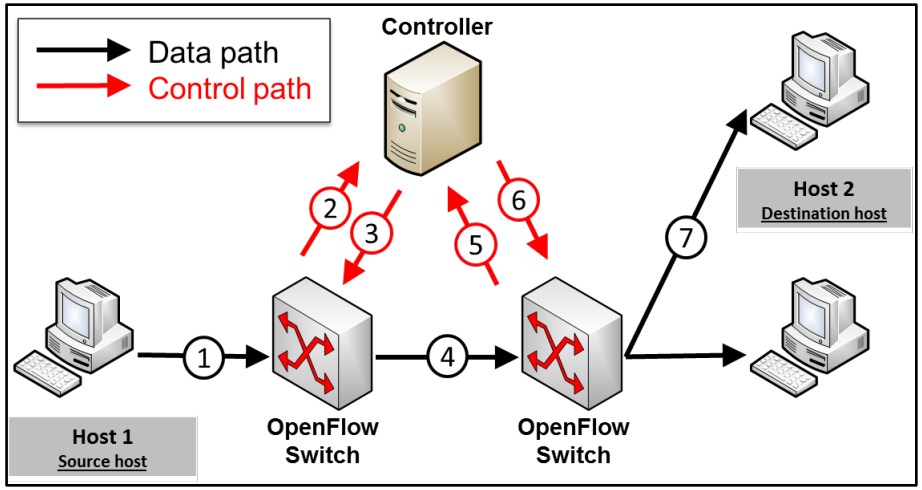


- Communication with OpenFlow switch
- Sending Packet-Out messages
- Sending Flow Modification messages

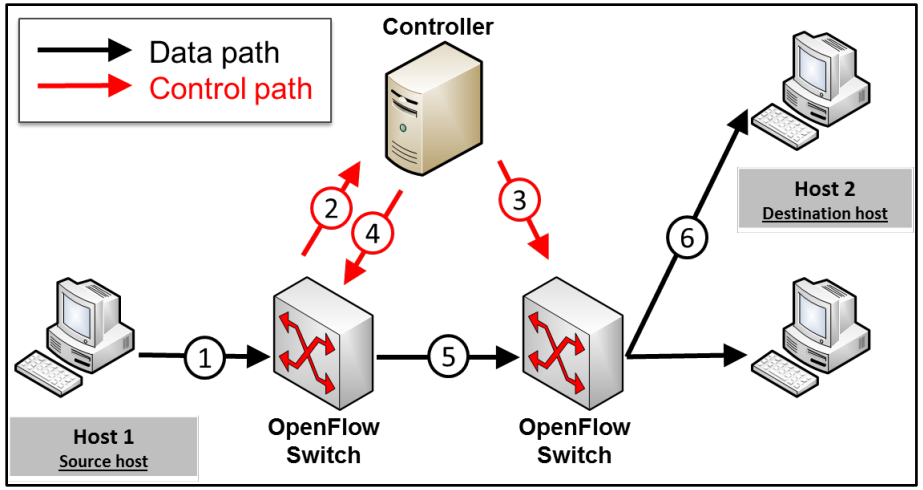
- Placeholder module
- Implemented behavior
  - Hub
  - Switch
  - Forwarding

Controller Behavior

- Switch behavior
  - Ordinary Ethernet switch
- Forwarding behavior
  - Flow mod messages are sent to all switches on path between source and destination



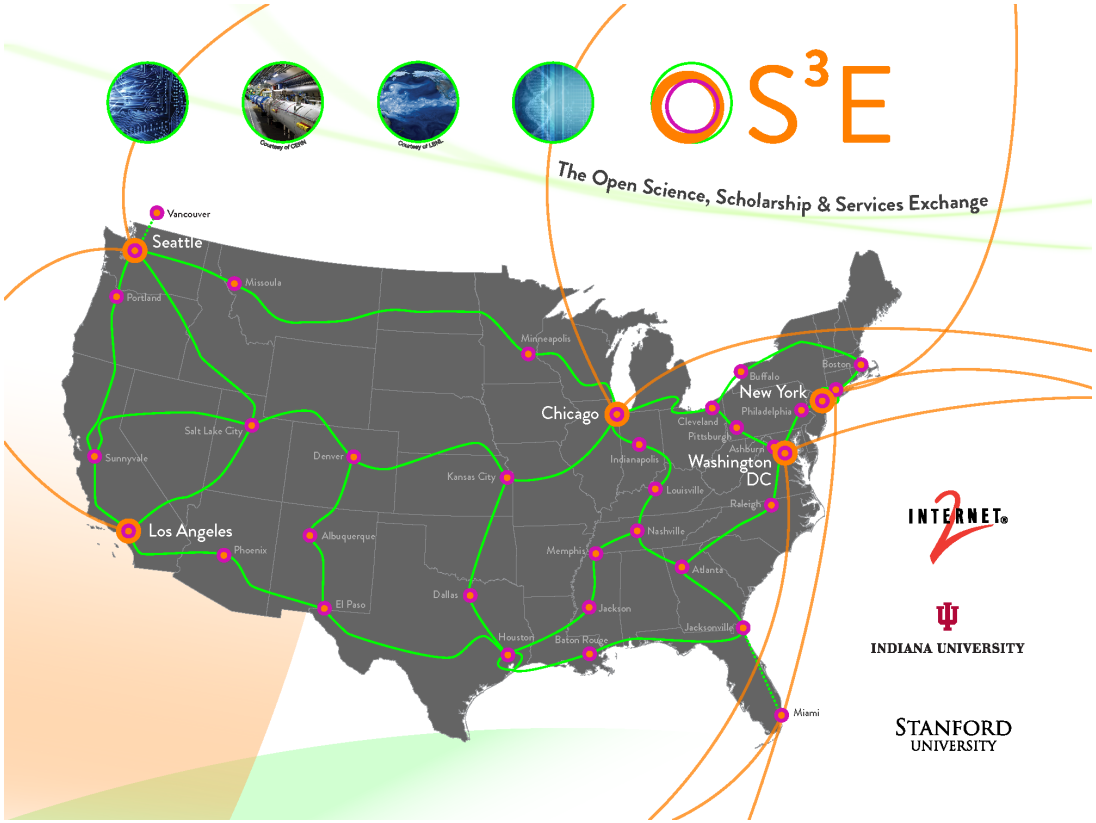
Switch controller behavior

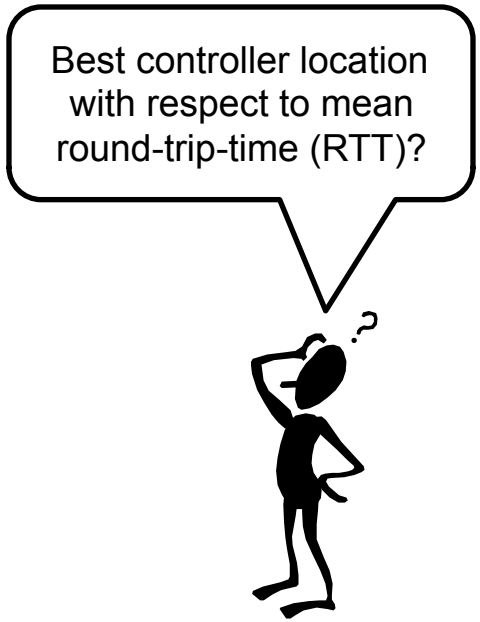


Forwarding controller behavior

Evaluation: Controller Placement

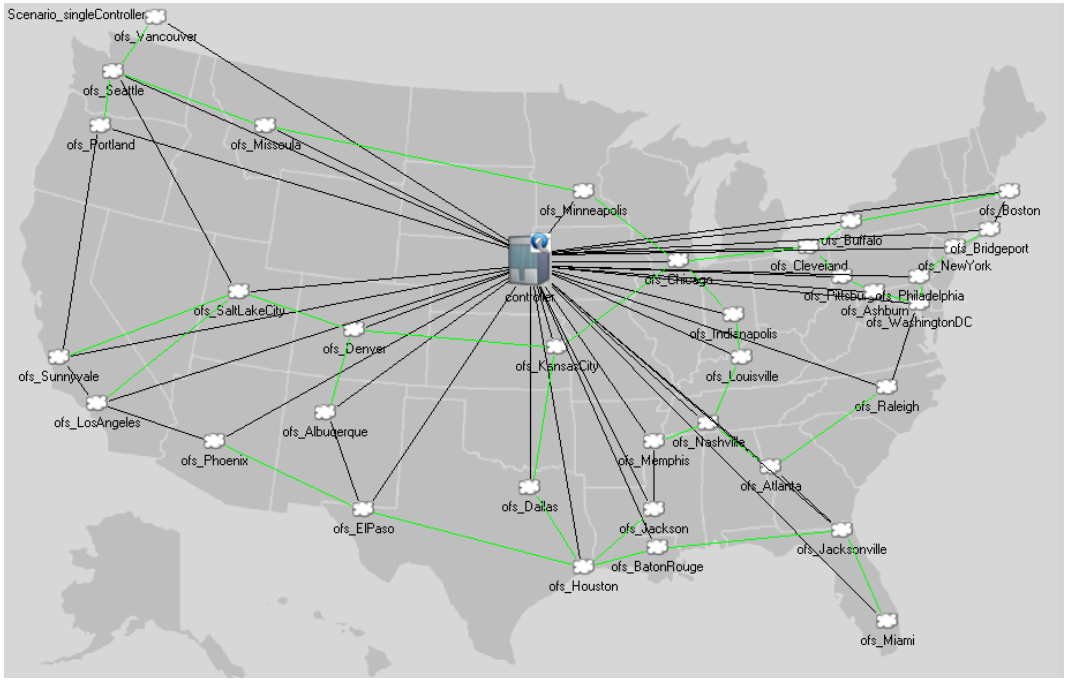
- Considered network
  - Open Science, Scholarship, and Services Exchange (OS^{3}E)
  - One of the first OpenFlow production deployments



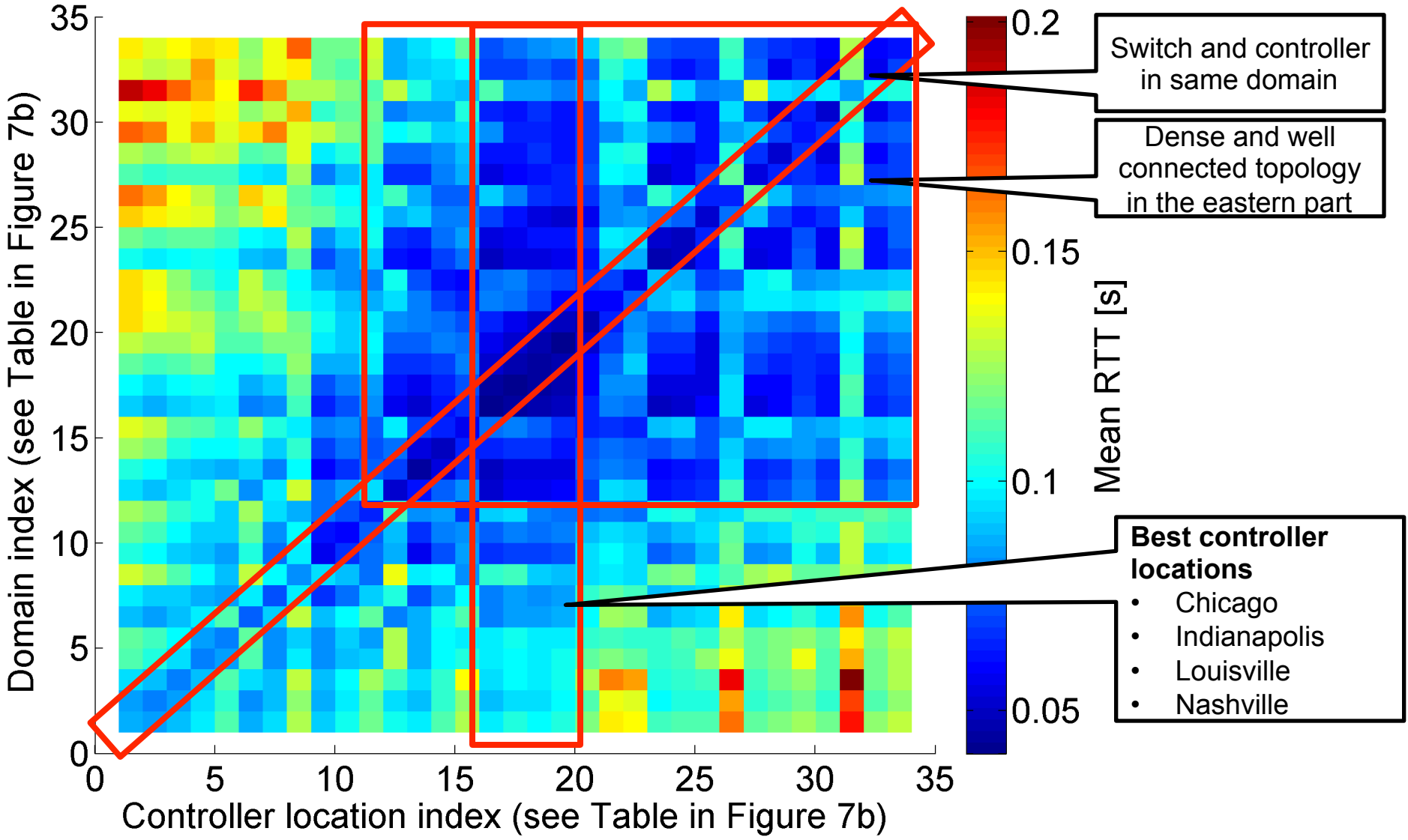


Evaluation: Controller Placement

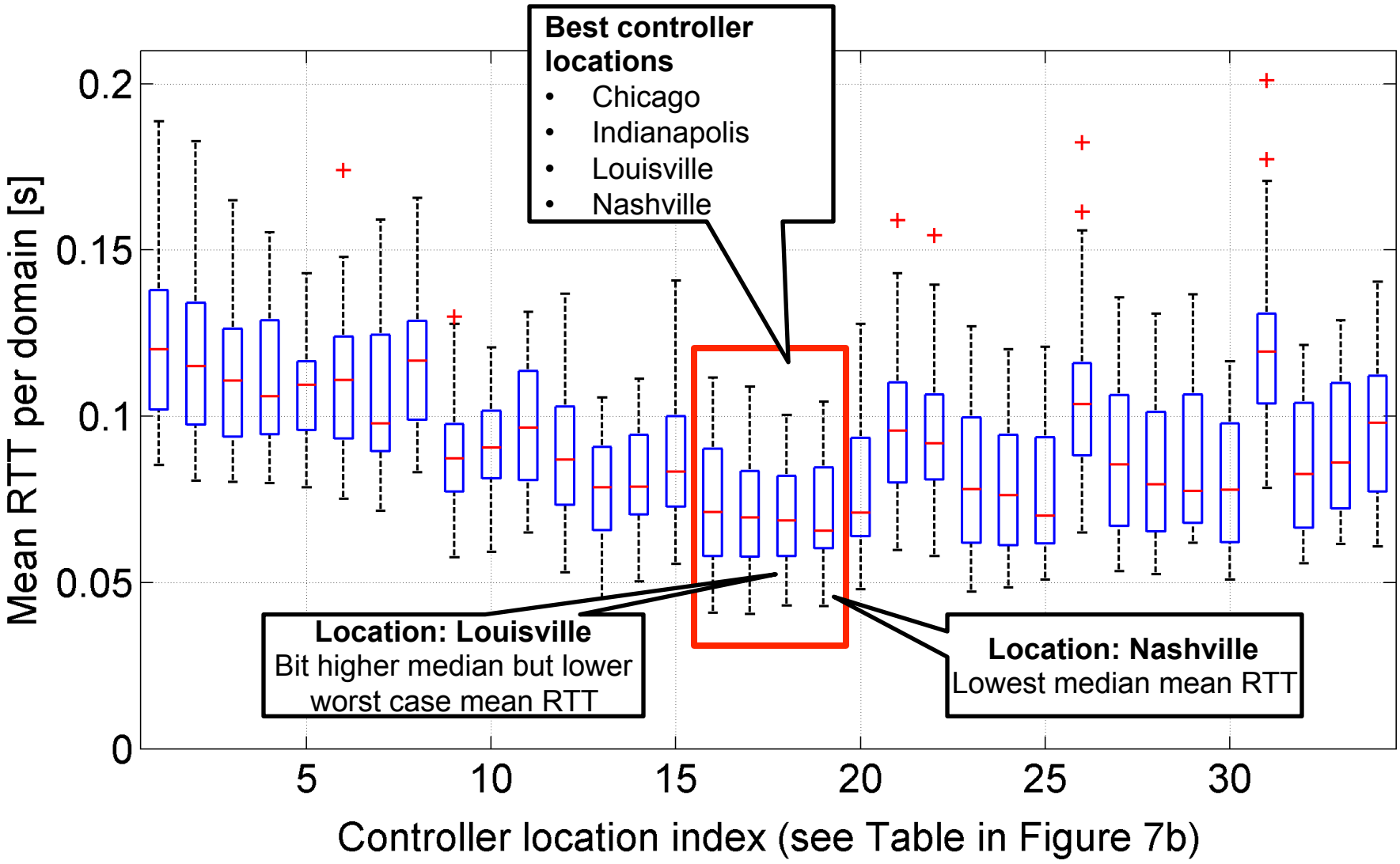
- Single Controller
  - Forwarding behavior
- Controller connected to all 34 OpenFlow switches
- Delay between the controller and a switch according to the data path delay
- Performance Metric
  - Mean RTT for each domain to all other domains
    - Host in each domain with ping app
    - Destination is chosen according to uniform distribution



Controller Placement Surface Plot



Controller Placement Boxplot



Summary

- Implementation of OpenFlow in OMNeT++
  - Extends and requires INET framework version 2.0
  - Based on OpenFlow header file
  - **Implementation according to OpenFlow specification 1.0**
- Proof-of-concept evaluation
  - Best controller location for OS^{3}E network
  - Only single controller architecture
- Future work
  - Implement and evaluate distributed controller architectures
  - Inter-controller communication
  - Resilience

Thank You for Your Attention

Code available at

➔ http://www3.informatik.uni-wuerzburg.de/research/ngn/openflow.shtml