Source Address Validation: from the Current Network Architecture to SDN-based Architecture

Jun Bi

Tsinghua University/CERNET

GFI 2013

Nov. 20, 2013

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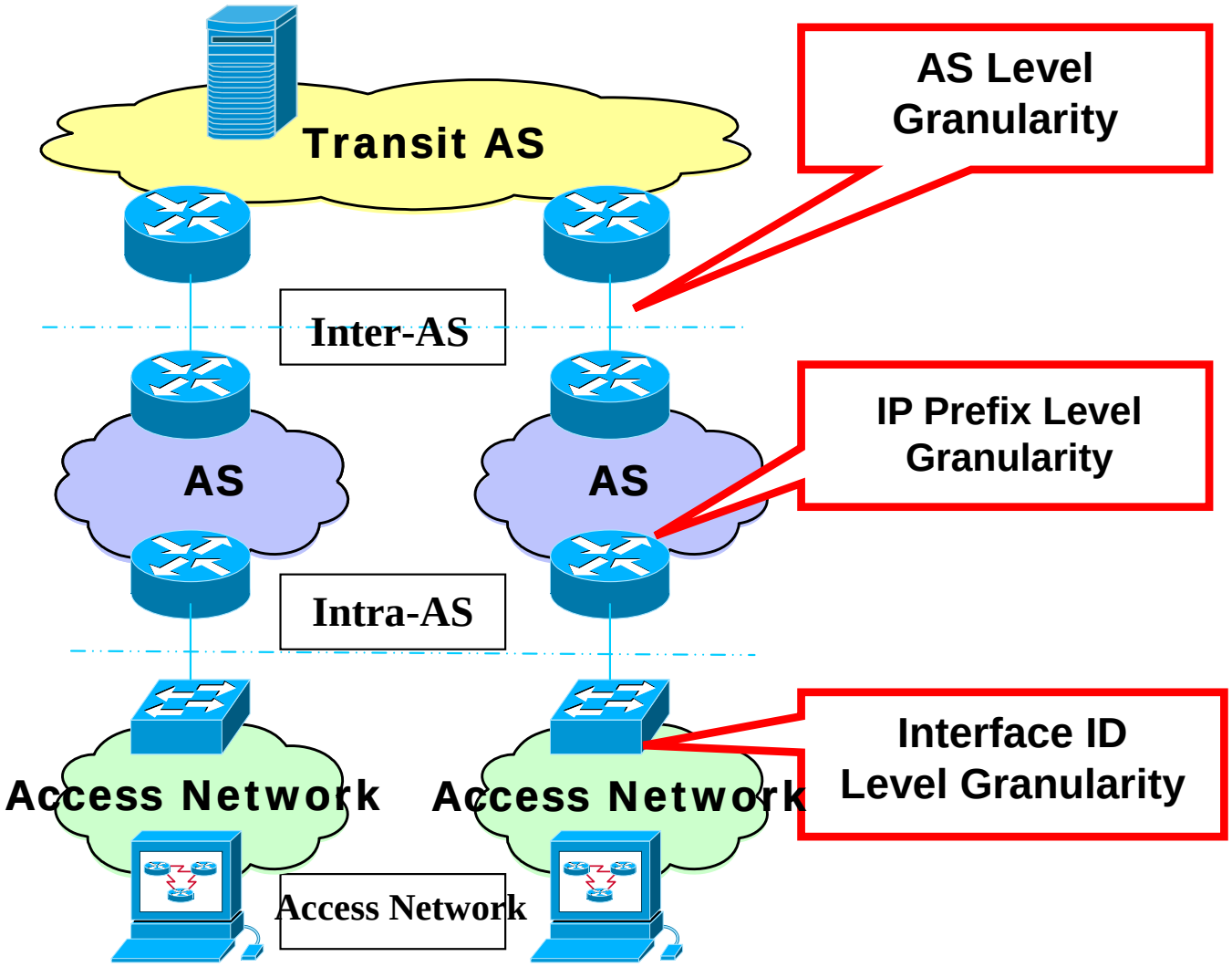
Source Address Validation Architecture (SAVA)

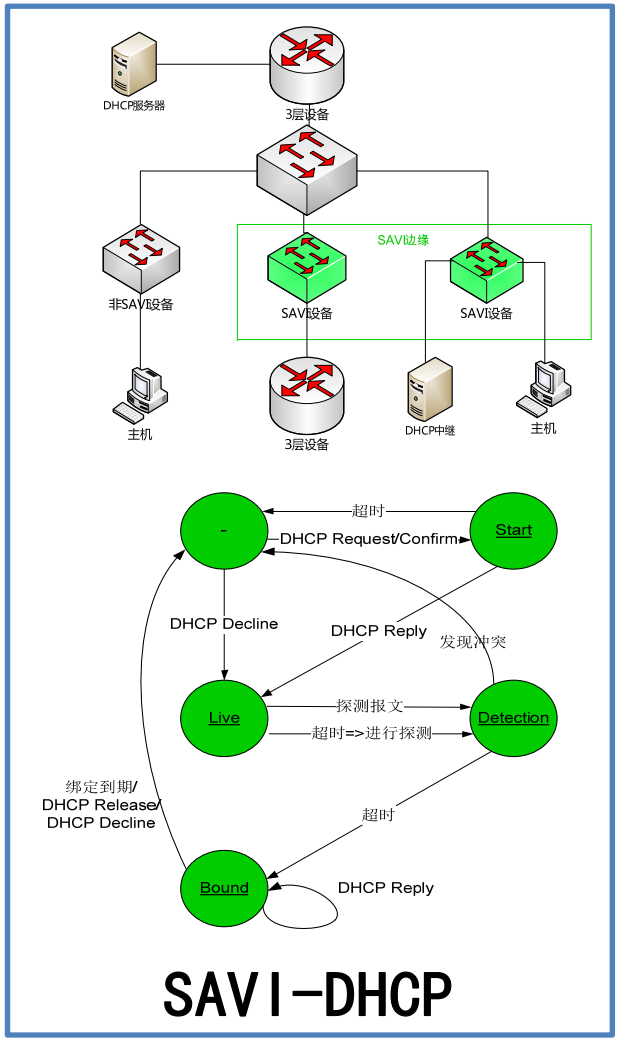
Source Address Spoofing

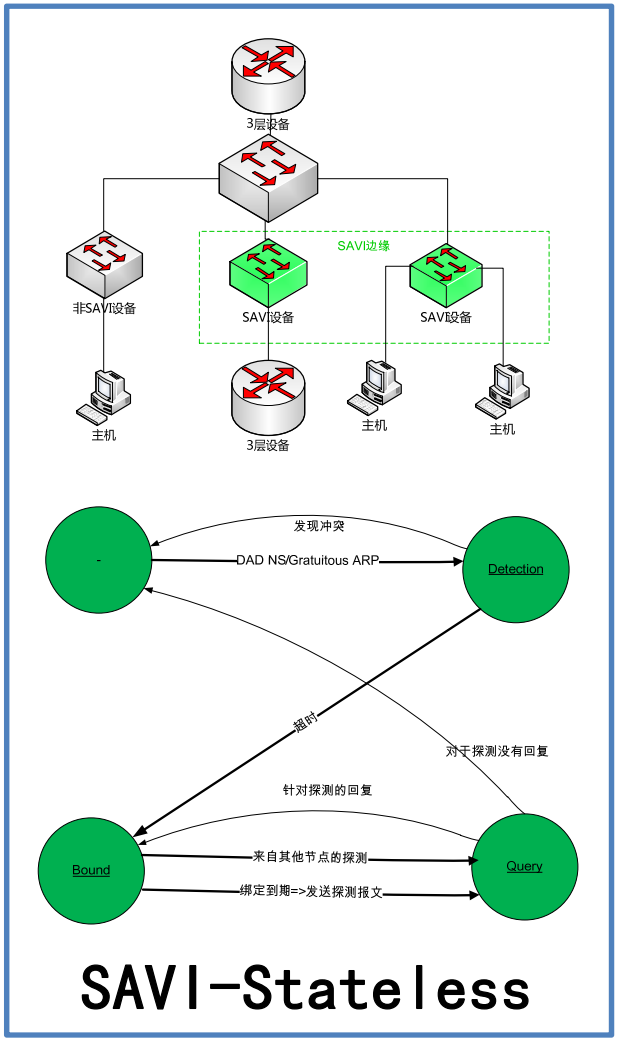
- Source address spoofing still a problem
  - Arbor Network annual network security report
  - MIT spoofer project
  - NANOG discussions
- Tsinghua university / CERNET proposed:
  - Source address validation architecture (SAVA) and solutions for IPv6
  - Solutions implemented, collaborating with domestic vendors
  - Deployed at CNGI-CERENT2 backbone and 100 universities' campus networks
  - Co-funders of IETF SAVI WG
    - RFC 5210 SAVA
    - RFC 7039 SAVI Framework

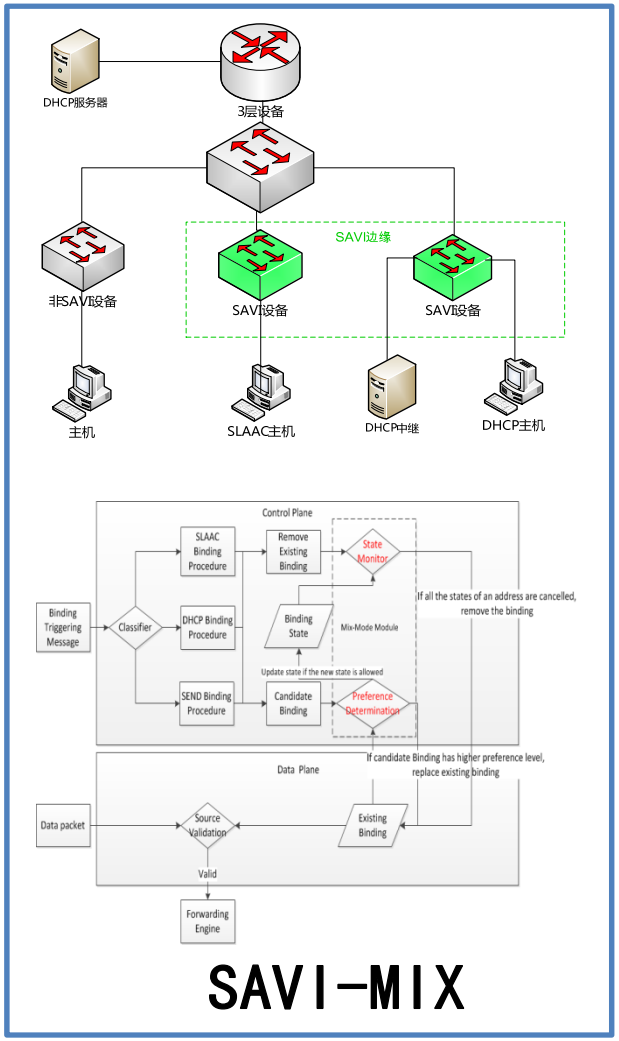
SAVA: Source Address Validation Architecture (RFC 5210)



Access Level: SAVI-CPS (Control Packets Snooping based SAVI)

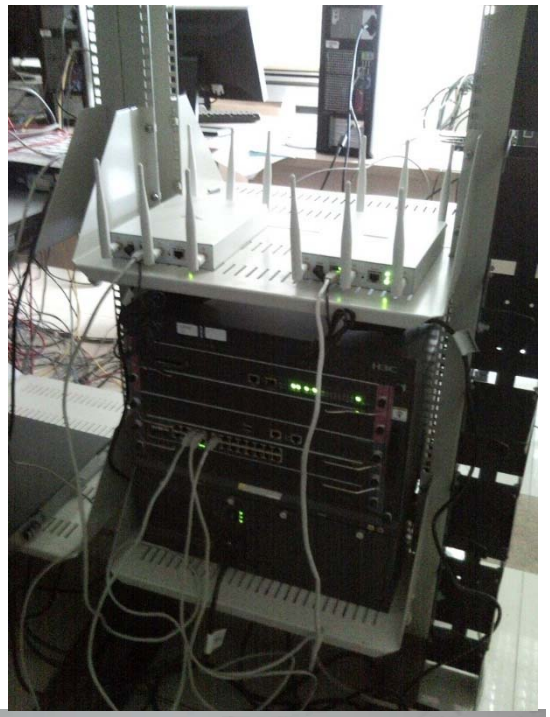




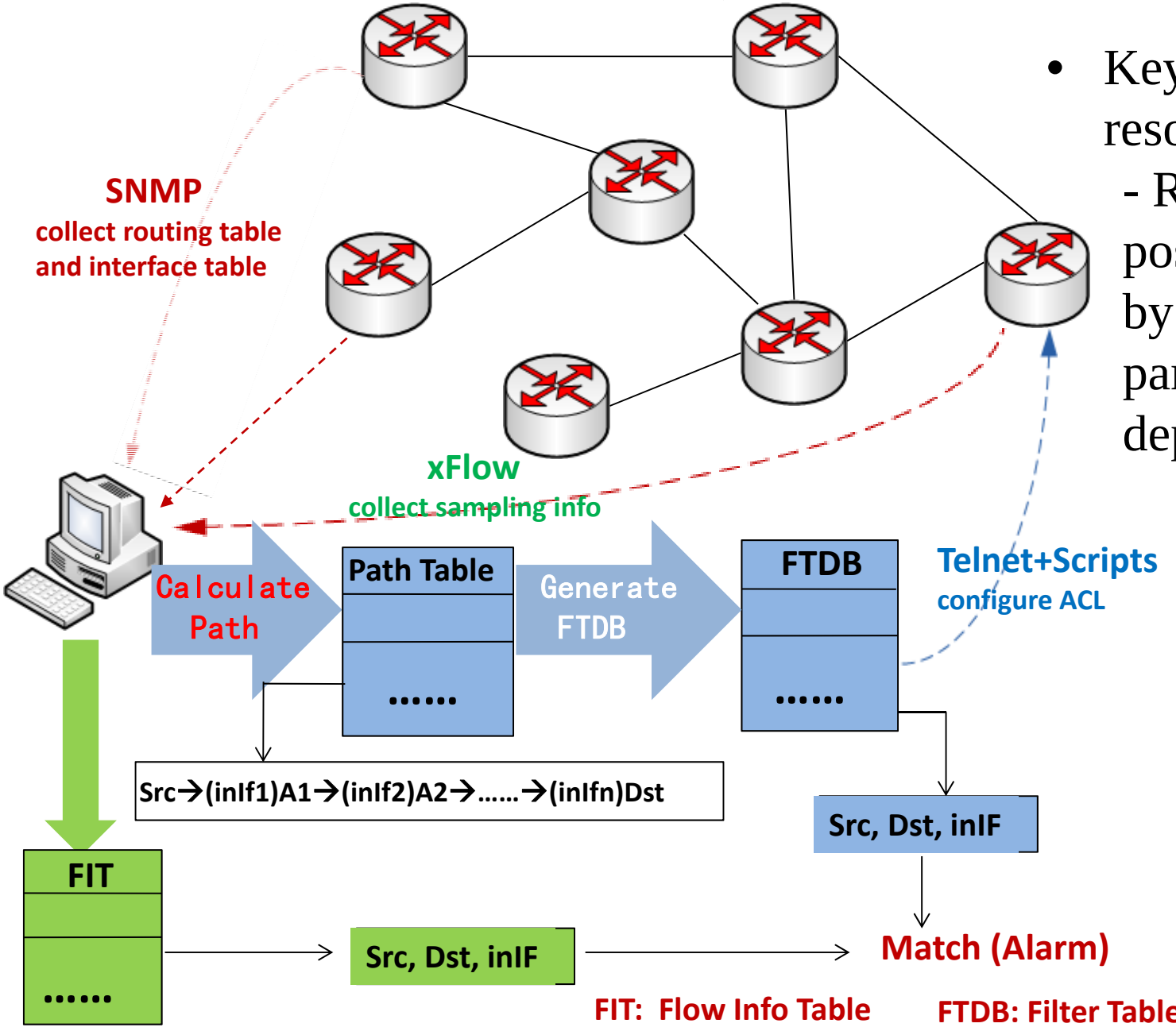


SAVI-CPS Implementation

- Huawei
- ZTE
- H3C
- Ruijing
- Digitial China
- Centac
- Bitwa
- L3/L2 switch, WLAN

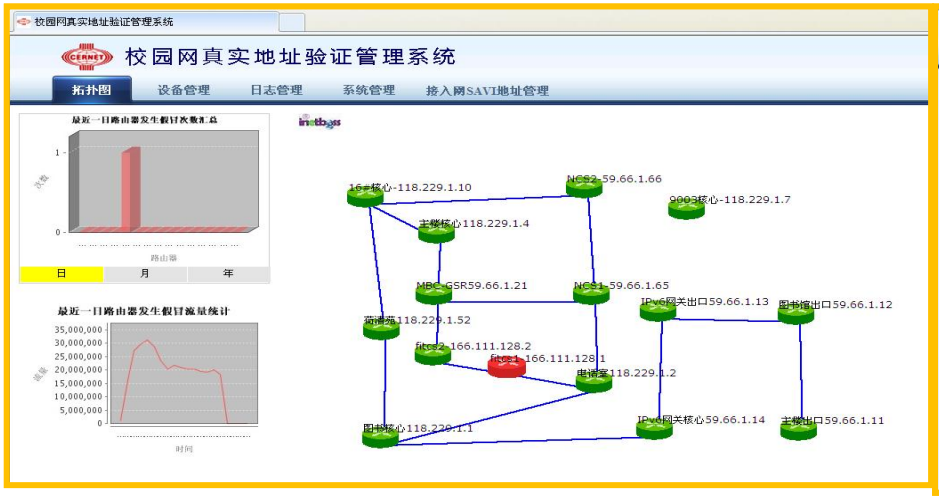


Intra-AS Level: CPF (Calculation based Path Forwarding)



- Key problem to resolve
  - Reduce false positive caused by uRPF at partial deployment

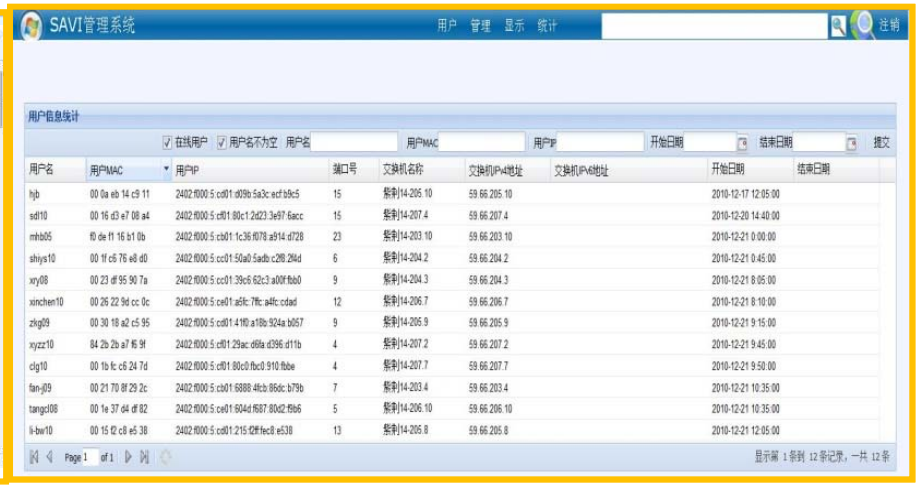
CPF Implementation



Topology mgmt

L3 devices mgmt

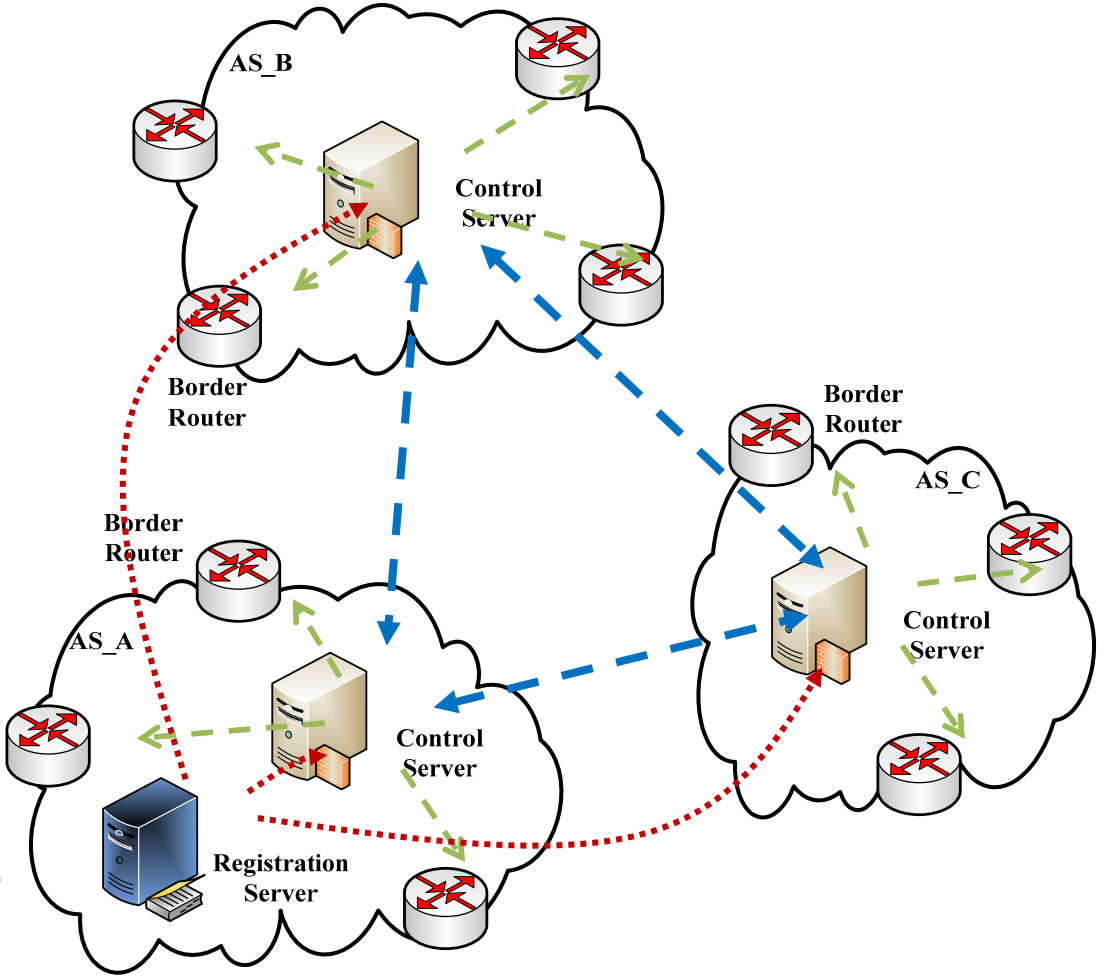
Spoofing alarm



SAVI user mgmt

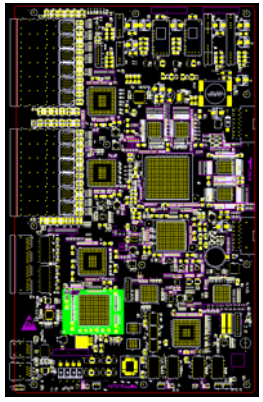
Inter-AS Level: SMA (State Machine based Authentication)

- Key problem to resolve
  - Incentive for deployment
- Trust Alliance
- ACS
  - Each member AS has a control server to negotiate parameter of SMs of each peer to trigger the same tag (random number) sequence
- ASBR
  - Add tags in IPv6 packets (in option header) and validate tags in destination
- Incentive
  - source address of Each AS can't be spoofed within the Alliance

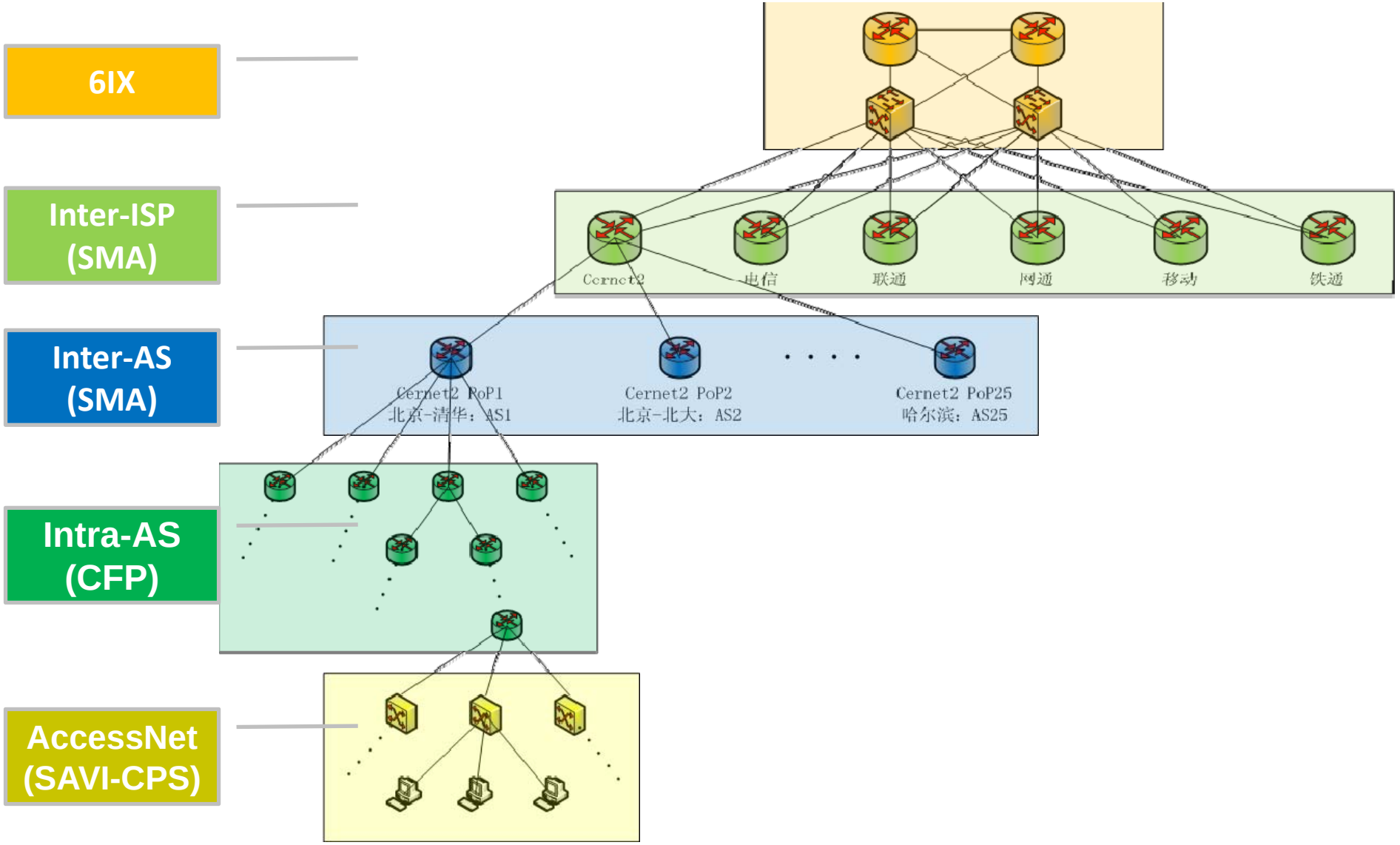


SMA Implementation

- Huawei NE40E core router line cards with 10G，GE ports
- Bitway BE12000 core router line cards with OC48, GE ports
- Centec special box with 10G, GE (co-located with legacy routers)



SAVA Deployment at CNGI-CERNET2



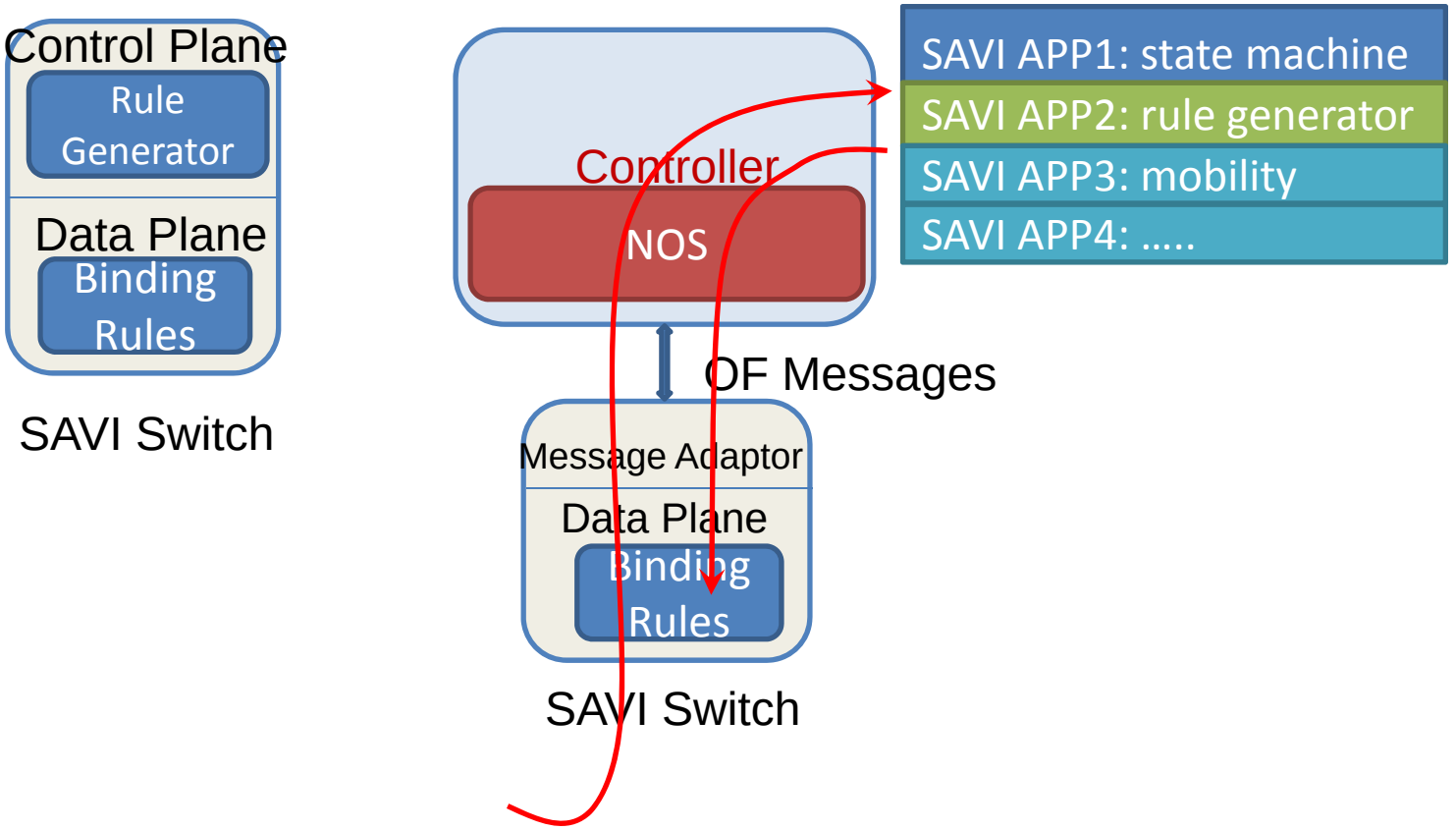
SAVA Deployment at CNGI-CERNET2

Leveraging SDN to enhance Source Address Validation

Motivations: enhancing Access

- Complex scenarios
  - Address assignment methods: Manual, SLACC, DHCP, SEND, Mixed, …
  - Access methods: LAN, WLAN, DSL, 3G, …
  - Mobility: local, across-network
  - Special cases: IPv6 transition, DNA, … addr. related new stuff
  - Solutions implemented at switches for all scenarios
    - Complex for design and implementation
    - Low efficiency (most scenarios are not common cases)
- Complex configuration
  - Coherent configurations for ALL switch ports at SAVI "perimeter" in the whole access network
- Can we migrate complexity from switch to server ?

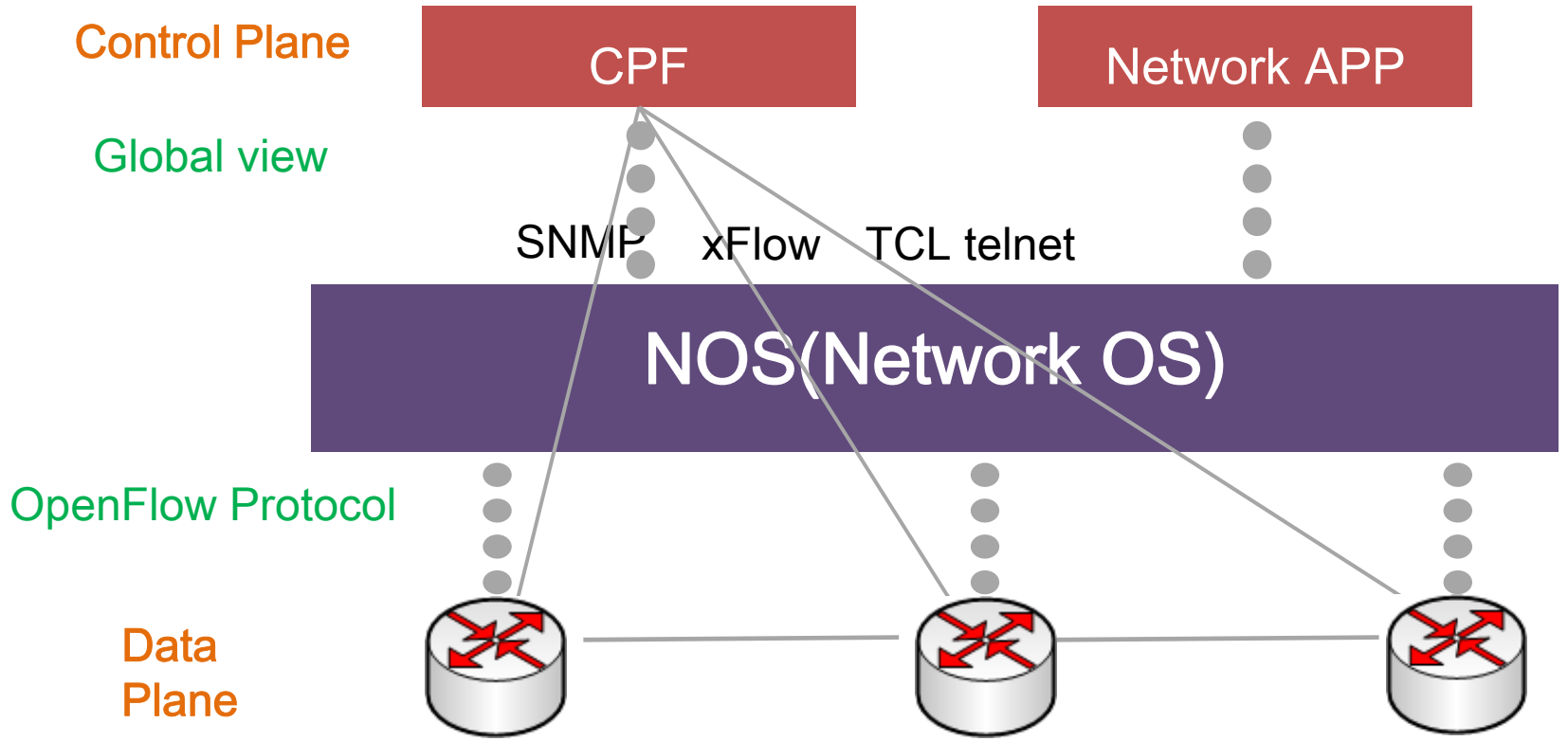
Software Defined SAVI (SDN-SAVI)

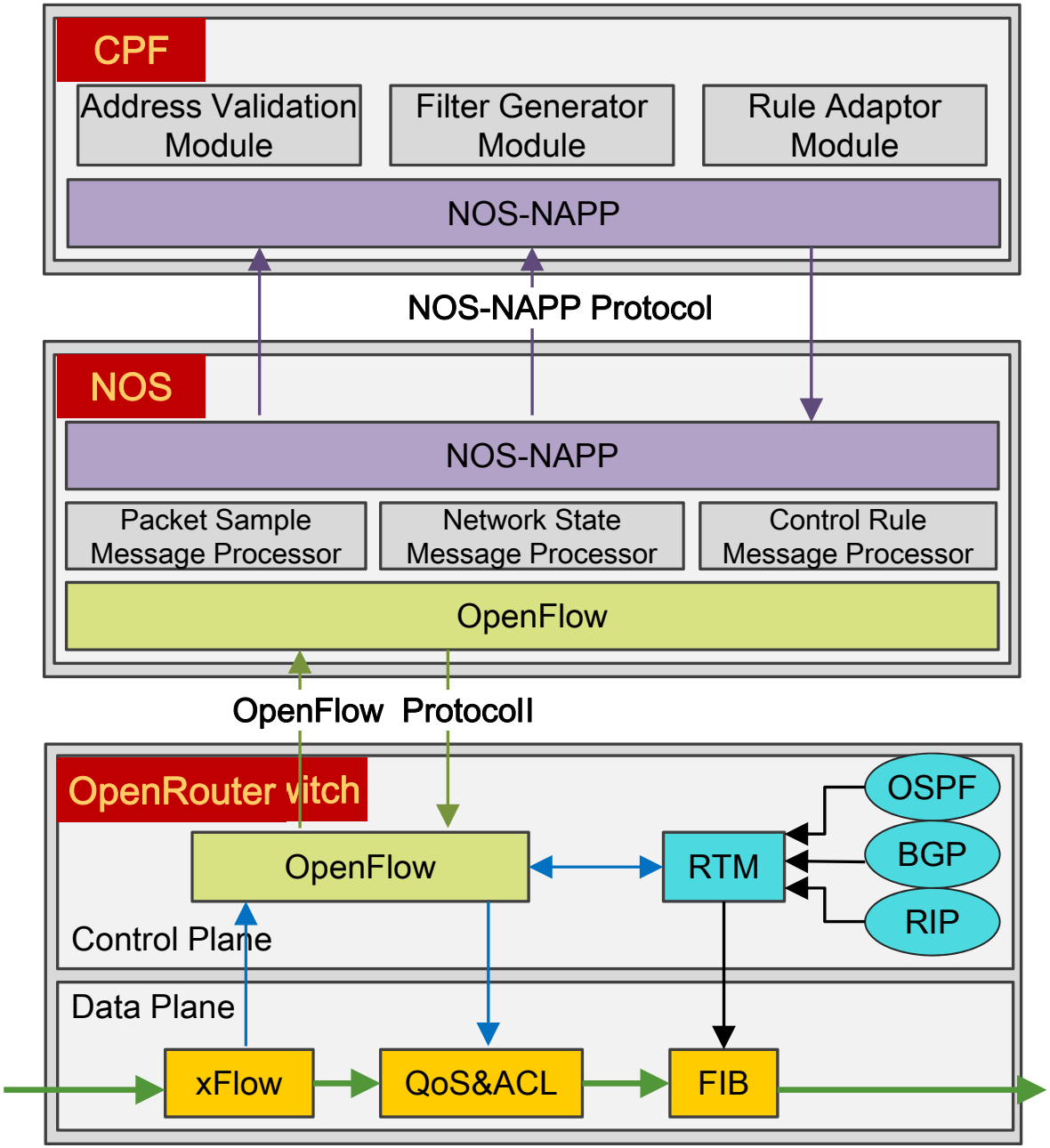


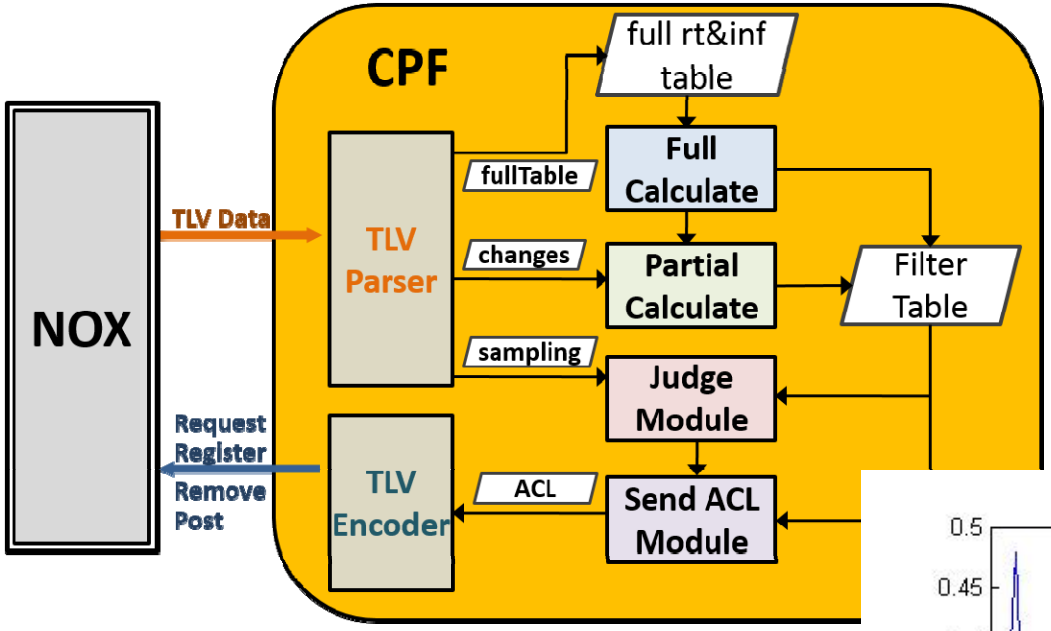
Motivations: enhancing Intra-AS

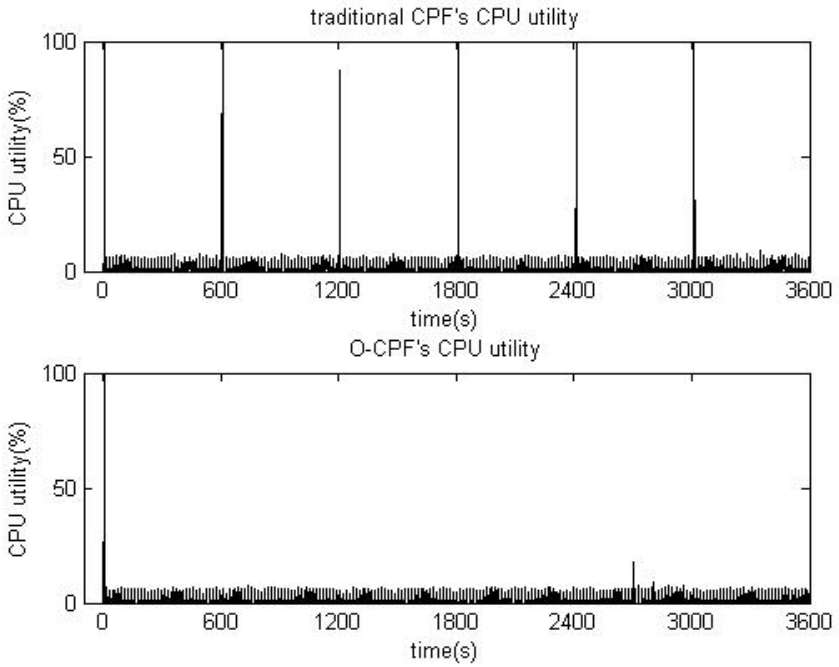
- Complexity to deal with legacy management and control interfaces
  - No unified MIBs (private MIBs)
  - No unified sampling protocol (sFlow, NetFlow, NetStream, etc)
  - No friendly programmable interfaces to configure ACLs (telnet + scripts are dangerous for production nets)
- Performance
  - Delay of network status update
  - Delay of control update
- Require unified and realtime mgmt/ctrl interfaces

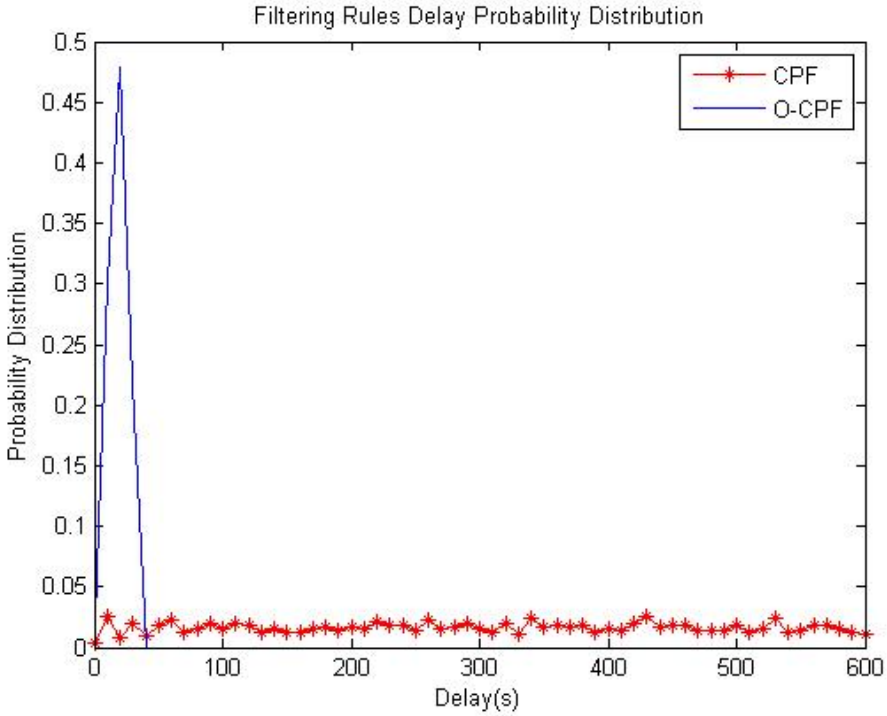
SDN based CPF




CPF
Address Validation Module
Filter Generator Module
Rule Adaptor Module
NOS-NAPP
NOS-NAPP Protocol
NOS
NOS-NAPP
Packet Sample Message Processor
Network State Message Processor
Control Rule Message Processor
OpenFlow
OpenFlow Protocoll
OpenRouter vitch
OpenFlow
RTM
OSPF
BGP
RIP
Control Plane
Data Plane
xFlow
QoS&ACL
FIB







Filtering Rules Enforcement Delay causes false positive, reflects the filtering effect

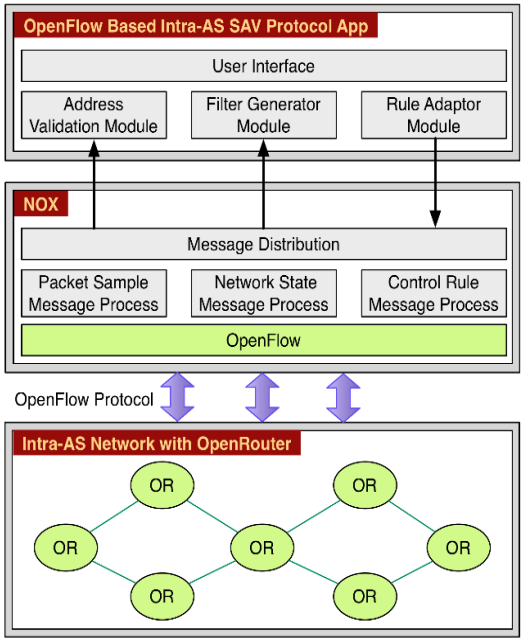
Demonstrated at INFOCOM2012

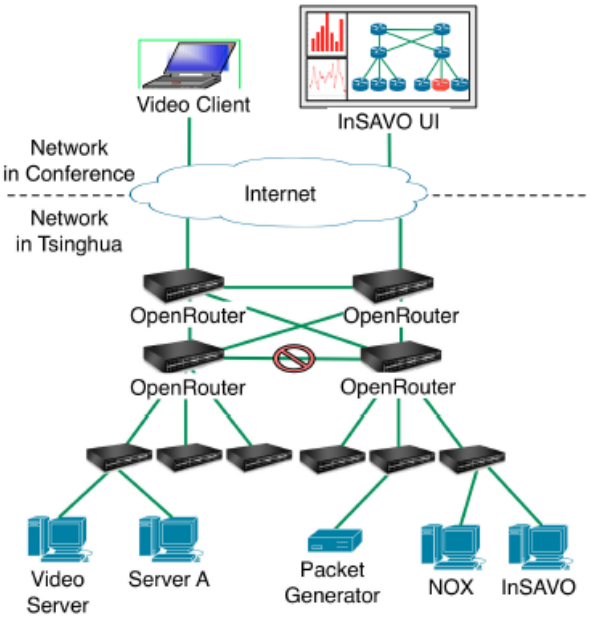
❖ **InSAVO: Intra-AS IPv6 Source Address Validation Solution with OpenRouter**

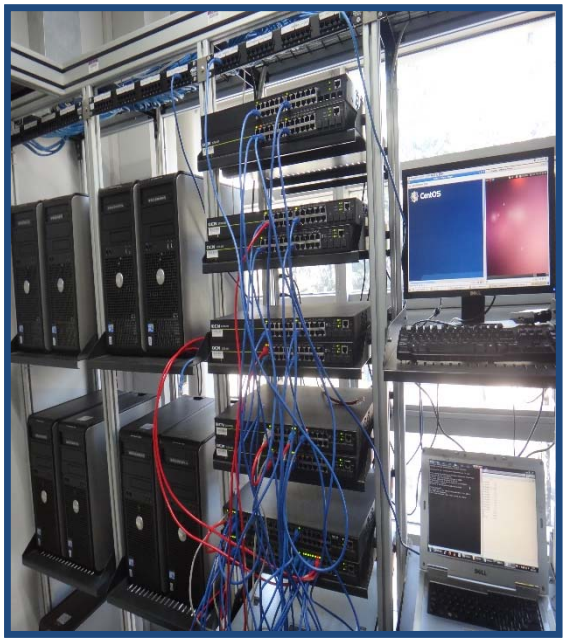
Central Control: To get a global forwarding path and then resolve false positive of filtering information caused by asymmetric routing more than ingress filtering.

Integrated Protocol: To takes place of SNMP/xFlow/Telnet in order to reduce the complication caused by multiple control interfaces with OpenFlow protocol.

Evolvable Deployment: To provide software-defined abilities by extending OpenFlow, but also give a tradeoff between existing hardware and evolution cost.







Motivations: enhancing Inter-AS

- Security: SMA uses lightweight tags for verification. An attacker might monitor packets in the backbone and replay the tag with spoofed packets
  - **Solution- cryptographic tags to prevent replay**
- Cost: Per-packet crypto marking incurs heavy data processing overhead beyond hardware capacity.
  - **Solution- on-demand defense to reduce overhead**
  - *"When"*: defend only attack is detected (cost effective)
  - *"Which"*: define *N* defense functions, chosen by operators by the type of attack
  - *"Who"*: only filtering the specific flows with self-benefit

CoFence: Collaborative On-demand Spoofing Defense

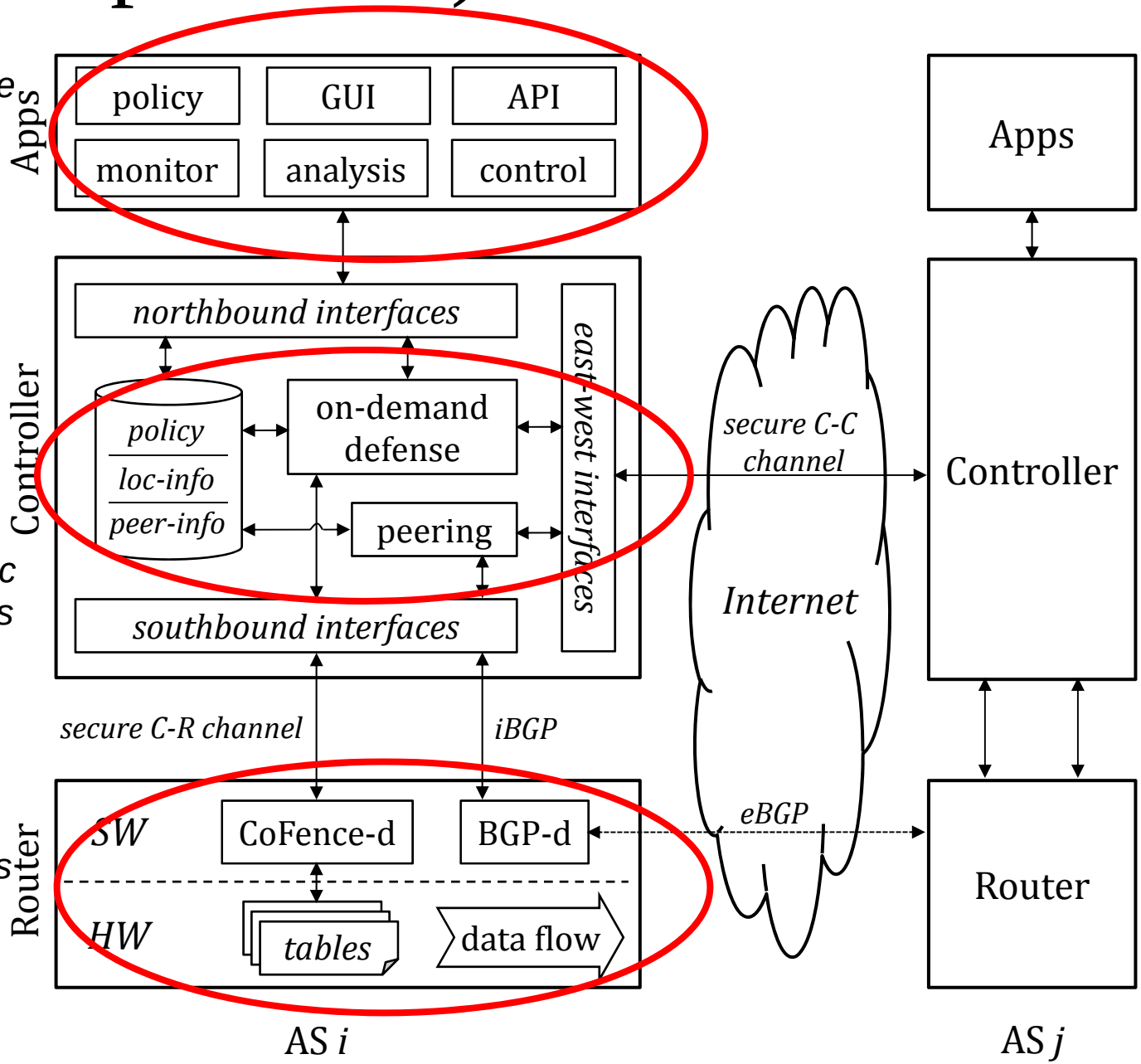
- Distributed inter-AS collaboration
  - Deployer discovery, peering and defense invocation
- Spoofing defense functions
  - Against d-DoS: DP and CDP (CDP uses crypto marking)
  - Against s-DoS: SP and CSP (CSP uses crypto marking)
  - Extensible: can define more functions
- Function invocation
  - Quadruple: (*function*, *parameters*, *prefix*, *time*)
    - *Function*: the function to be invoked
    - *Parameters*: parameters for the function (e.g., keys for crypto)
    - *Prefix*: the src/dst prefix to be protected
    - *Time*: the time duration for this invocation
- These lead to SDN-based design

SDN (not OpenFlow) based CoFence

Higher-layer features can be added in apps, e.g., attack monitoring, traffic analysis, AS-wide policy and control, manual-config GUI and auto-config APIs for IDS.

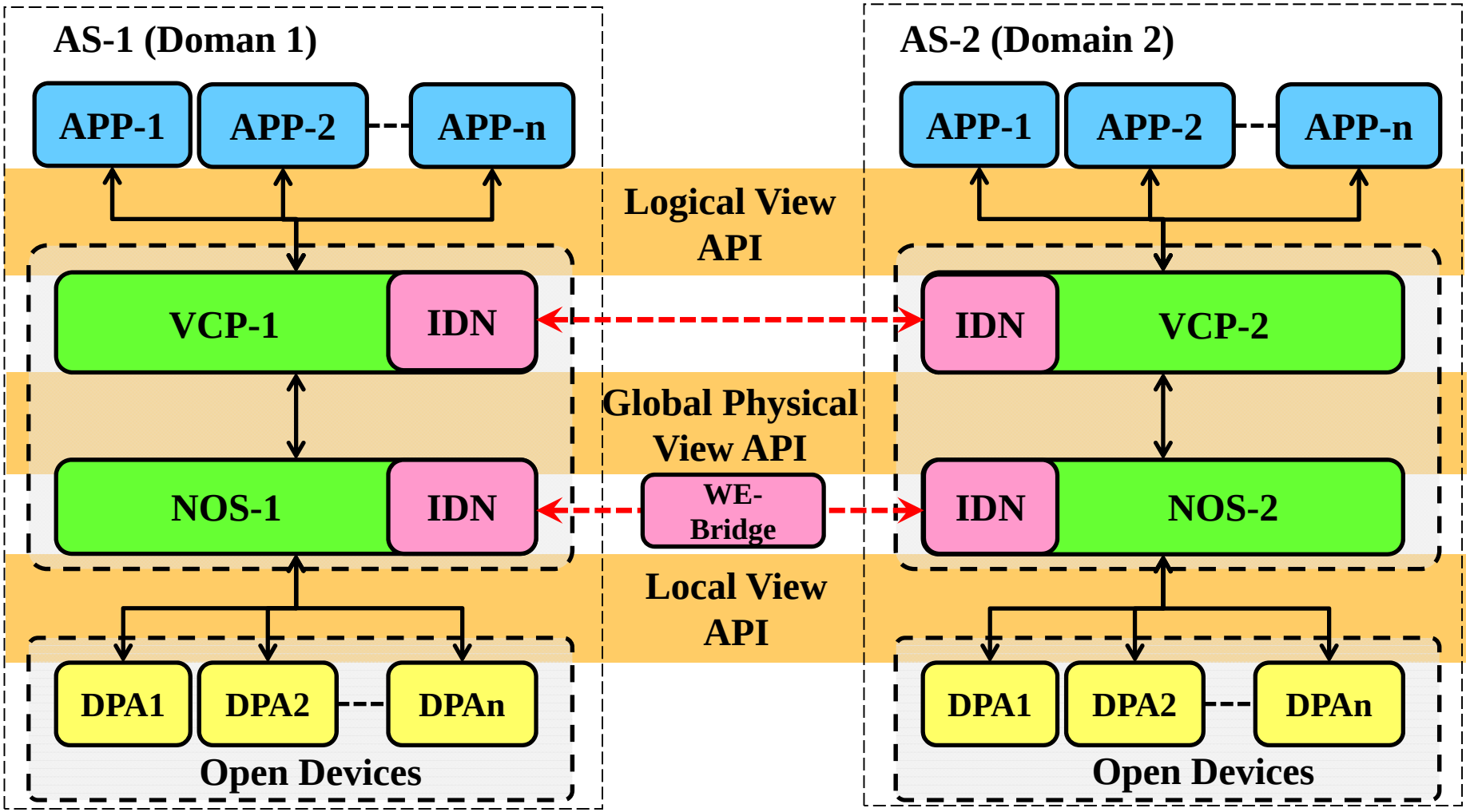
Controller communicates with other domains, and bridges apps with routers, using SDN interfaces. It provides CoFence-specific functionalities and maintains domain-wide information.

CoFence-d communicates with controller and manages tables to define data-plane behavior.



“WE-Bridge” proposed in *FINE*

- *WE-Bridge* proposed in China 863 High-tech R&D project *FINE*
- Demoed at CANS13 and SupterComputing2013



Conclusion

- SAVA and solutions
  - Architecture
  - Access level: SAVI-CPS
  - Intra-AS level: CPF
  - Inter-AS level: SMA
  - Implementation, and deployment at CNGI-CERNET2
- Leveraging SDN to enhance Source Address Validation
  - Motivations
    - Handling complexity
    - Providing agility
    - Improving performance
  - Programmability is key to decoupling infrastructure and functionality (to migrate the complexity to APPs)
  - Leveraging centralized view for access (e.g. configuration, mobility) and intra-AS, and negotiated view for inter-AS SAV

清華大學

Thanks!