



## WE-Bridge for an Inter-domain SDN testbed among CERENT-CSTNET-Interen2-SURFnet

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## Content

- WE-Bridge Motivations
- WE-Bridge Mechanisms
- WE-Bridge Applications
- Short Demo: a Fine-granularity Inter-domain Routing
  - Inter-domain SDN application: Source and destination based routing and multipath forwarding)
  - Demo in the Inter-domain SDN testbed among CERENT-CSTNET-Interen2-SURFnet
- Conclusions and Future Work

## Contributors

- |   |                                 |                             |
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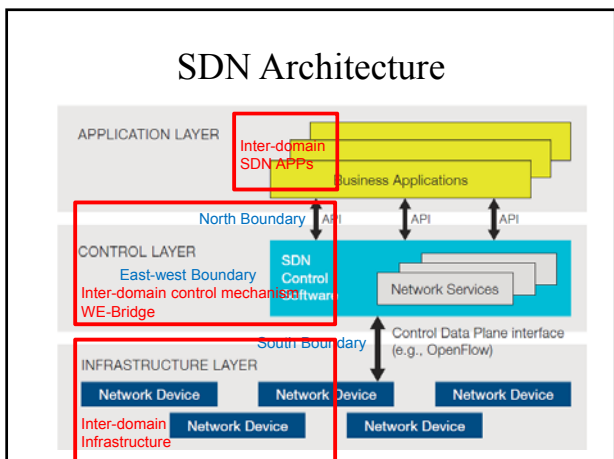
## Milestones

- Common interests on SDN collaboration agreed during CERNET-Internet2 10G connectivity opening ceremony (Beijing, June 2012)
- FIWG formed at CANS2012 (Seattle, Oct. 2012)
  - SDN/FI WG charter includes CERNET-CSTNET-INTERNET2 joint SDN testbed as “Initial project”
- Inter-domain SDN testbed plan and design was discussed at TIP/APAN/Internet2 meeting (Steve and Jun, in Honolulu, Jan. 2013)
- Implementation phase
  - A varied version (by Tsinghua and Open Networking Lab, etc. collaboration) demonstrated at SIGCOMM 2013 (Hongkong, Aug. 2013)
- Review meeting during IETF87 (Scott and Jun, in Berlin, July 2013)
- CAN2013 Demo for one application, Sep. 2013
- SuperComputing2013 Demo for another application, Nov., 2013

## WE-Bridge Motivations

## Why SDN?

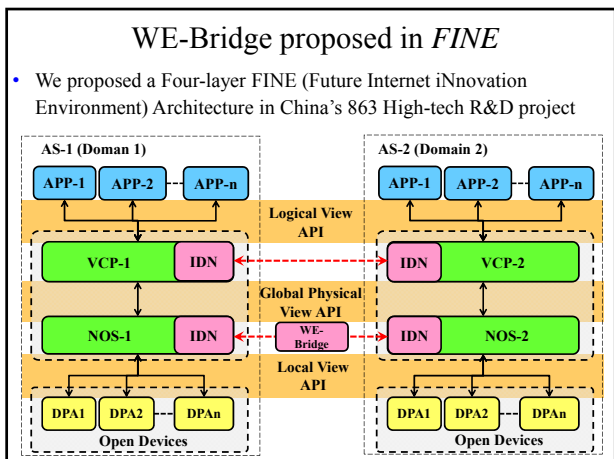
- Software defined networking (SDN) is one of the hottest topics in networking area
- Openness
  - decouples the vertical and tightly coupled network architecture, and opens up the control plane and the associated protocol
- Agility
  - SDN enables more **flexible** network control and management
  - SDN promotes the **rapid** innovation and the evolution of the network
- SDN is considered as a promising way to re-architect the networks.



- ### SDN Research Challenges
- Inter-domain (Shall we provide real topo., full control to others ?)
    - The Internet are managed by owners of different domains, which makes the centralized control doesn't work for inter-domain
  - Scalability
    - Centralized control could not scale to a very large network (may work for a data center or a campus, but not Internet scale)
  - Use cases
    - To improve the feasibility in real world
  - Other Challenges
    - Data plan
    - Security
    - ...

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- Inter-domain
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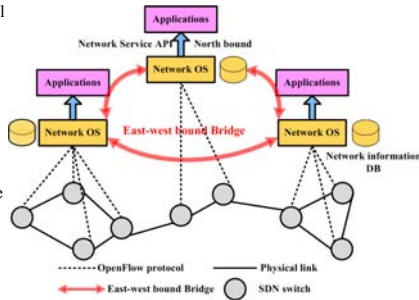
- ### SDN Peering Design Goals
- Inter-domain
    - Change centralized resource control by global network view → *negotiation* on inter-domain resource by *exchanging domain views*
  - Scalability
    - Change logical or physical centralized control → *distributed* mechanism for Internet scale
  - Use cases
    - We developed 4 use cases and demos matching the *needs of real world*
  - Other Challenges
    - Data plain
    - Security
    - ...



## WE-Bridge Mechanisms

## West-East Bridge for SDN Peering

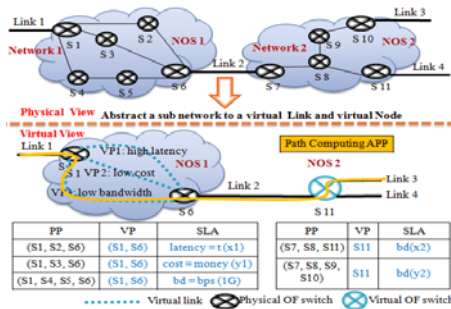
- Each NOS gathers local network view, then exchange domain view among heterogeneous NOSes by WE-Bridge
- An APP requires resource in other domains by WE-Bridge NB-API
- APPs in other domains may accept or deny the request (Negotiation details will be determined by APPs)



## WE-Bridge Mechanisms

- Domain view abstraction
  - What network view information to be exchanged
  - Could just provide virtualized domain view (to deal with security/privacy, reducing complexity)
  - Storage and exchange format
- SDN peering mechanism
  - Peering set-up and controller discovery
  - High performance information exchange
  - Finite State Machine
- WE-Bridge Implementation

## Domain View Abstraction: Virtualization

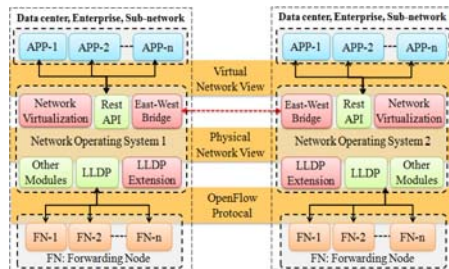


Physical view to virtual view (PP: Physical Path; VP: Virtual Path; OF: OpenFlow; S: Switch; bd: bandwidth; t: time; bps: bits per second)

## SDN Peering: Information Exchange

- All the SDN peers are equal to each other.
- Peering set-up is like BGP peering
- For the network event, such as failures, virtual topo changes, policies changes, each controller can subscribe to other controllers' events.
- A Publish/subscribe system to trigger/deliver update messages:

## WE-Bridge Implementation



- Enable WE-Bridge in all kinds of NOSes by adding three modules:
  - Network Virtualization, East-West Bridge, and LLDP Extension

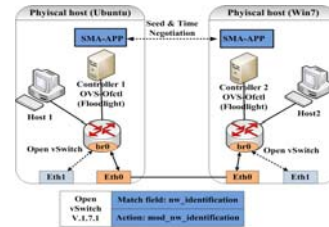
## WE-Bridge Applications

## Inter-domain SDN Applications

- ▶ We designed and implemented **Four** use cases based on WE-Bridge:
  - Case1: **Inter-domain Source Address Validation**
    - Implemented in **Tsinghua Testbed**
  - Case2: **Seamless BGP Interworking of SDN and IP**
    - Implemented in **Open Networking Lab, USA/ Tsinghua Univ. Collaboration**
    - **Demo on Aug. 14, 2013 at SIGCOMM13, Hongkong, China**
  - Case3: **Inter-domain Path Computing**
    - Implemented in **CANS Testbed (CERNET-Interent2-CSTNET)**
    - **Demo on Sep. 11, 2013 at CANS13, Hangzhou, China**
  - Case4: **FlexPath: a Fine-granularity Inter-domain Routing**
    - Implemented in **CERNET-CSTNET-Interent2-SURFnet testbed**
    - **Demo on Nov.17-22, 2013 at SuperComputing13, Denver, USA**

## Use Case #1: Inter-domain Source Address Validation

- Inter-domain Source Address Validation App (ID-SAV-App)
  - **Open vSwitch**
  - We **extended a match field in Open vSwitch** by adding an 'nw\_identification' field. Also we **extended an action** in Open vSwitch, and added a 'mod\_nw\_identification' action.



## Use Case #2 Demo at SIGCOMM13 (Aug. Hongkong)

This block contains information about the demo at SIGCOMM13. On the left, there is a diagram titled 'Architecture of SDN-IP Network Peering' showing the interaction between SDN-IP Peering Application, BGP Route, and IP routing application. Below it is a 'Transition' diagram showing the flow from traditional IP routing to SDN. To the right, there are three photos showing the demo setup and attendees at the conference. Below the photos, there is a table for 'MAC Address Rewriting and Layer 2 Forwarding':

Part	Source	Destination	MAC
Part X	Source domain in Host 1 (server)	Host 2	mac1_2
Part Y	Source domain in Host 2 (server)	Host 1	mac2_1
Part Z	Source domain in Host 1 (client)	Host 2	mac1_1
Part W	Source domain in Host 2 (client)	Host 1	mac2_2

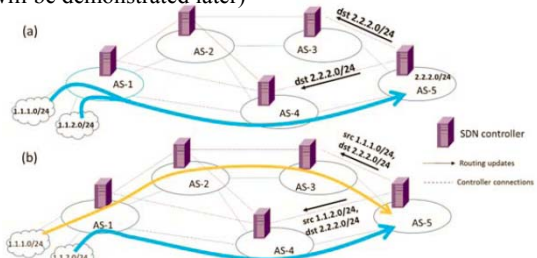
## Use Case #3 : Inter-domain Path Computation for Genomics Data Transfer Demo at CANS13 (Sep. Hangzhou)

This block contains information about the demo at CANS13. It features a presentation slide titled 'Demo Genomics Data Transfer on the Inter-domain path set up by WE-Bridge for CERNET-CSTNET-Interent2 SDN Peering'. The slide lists the organizers as CANS EWG, Hangzhou, Sep. 11, 2013, and mentions the authors: Xudong Sun, Xiang Gao, and Yuhao Wu (CSTNET). It also lists the sponsors: Anhui (CERNET) Hangzhou and Yuhao Wu (CSTNET). The presenters are listed as Pengfei Liu (from California), Ze Chen (Beijing), and Xudong Sun (Hangzhou). To the right of the slide are several photos showing the demo setup and attendees at the conference.

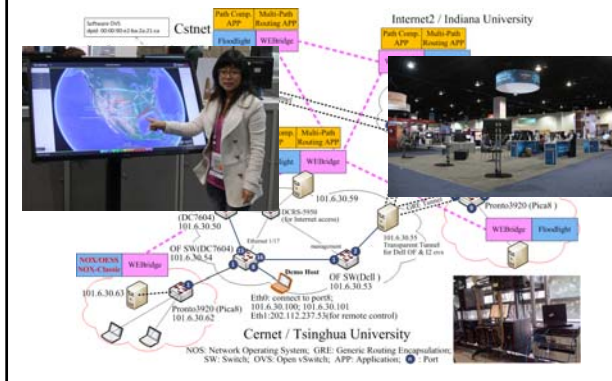
This block shows screenshots of network monitoring and management tools. The top part shows the 'Path Computing APP' interface with a graph of traffic volume over time. Below that, there are screenshots of the 'Floodlight' controller interface showing network flows and topology. The network topology includes nodes like 'OF SW(DC7604)', 'DCRS-990', and 'Tsinghua'. A specific IP address '101.6.30.53, port 1 (OF SW Demo)' is highlighted. The bottom part shows a 'Flows (R)' table with columns for ID, Name, Ingress Port, Egress Port, and Action.

## Use Case #4: Fine-granularity Inter-domain Routing

- Fine-granularity routing policy based on source prefixes: two paths from different sources to the same destination (will be demonstrated later)



Use Case#4 Demo at SuperComputing13(Nov. Denver)



**Short Demonstration**

**Conclusions and Future Work**

- Conclusions**
- To scale SDN to the global level, we need distributed inter-domain SDN
  - WE-Bridge is the very first *distributed* and automatic (East-west Boundary APIs) Inter-domain SDN mechanism
    - **Distributed** domain views exchange
    - NB-APIs provided to APPs for inter-domain resource **negotiation**
    - Preliminary WE-Bridge **deployment** at SDN domains in CERNET, INTERNET2, SURFnet, and CSTNET
  - Various **inter-domain applications** can be easily and quickly deployed upon WE-Bridge
    - Four applications are introduced

- Future work**
- Plan to extend the inter-domain testbed.
    - BUPT will join soon
    - Call for participation for other SDN testbeds in Asia to join us
  - More APPs and use cases
  - Next possible demonstration
    - Interent2 meeting
    - CANS2014, New York, Sep. 2014

**Thanks !**