EASE NETWORK FUNCTION PROGRAMMING IN DISTRIBUTED CONTROL PLANE

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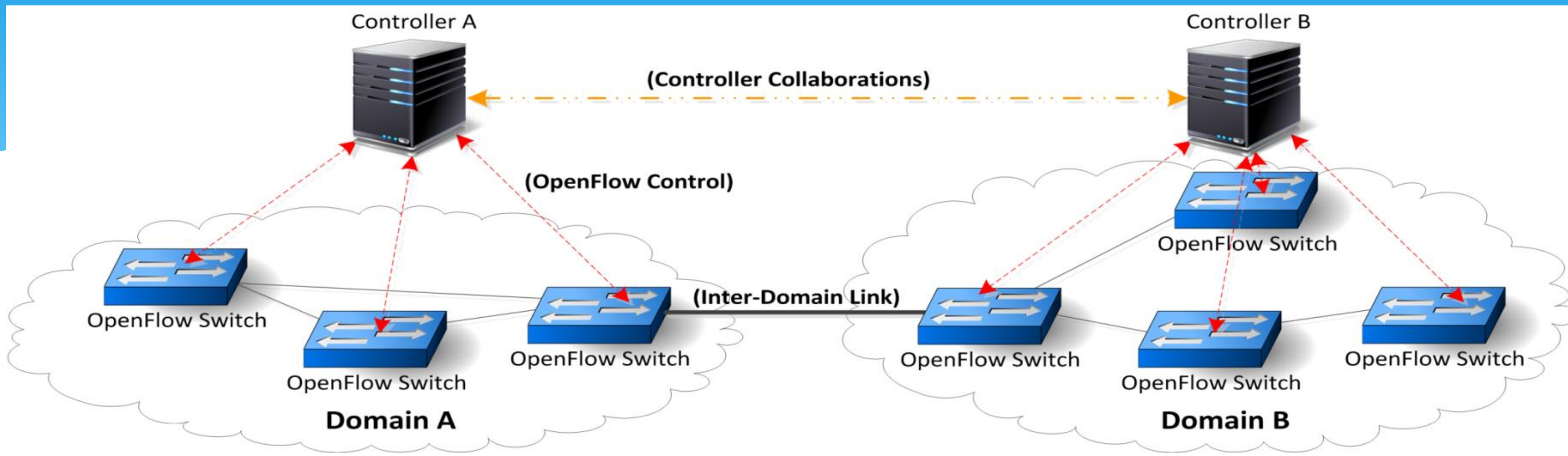
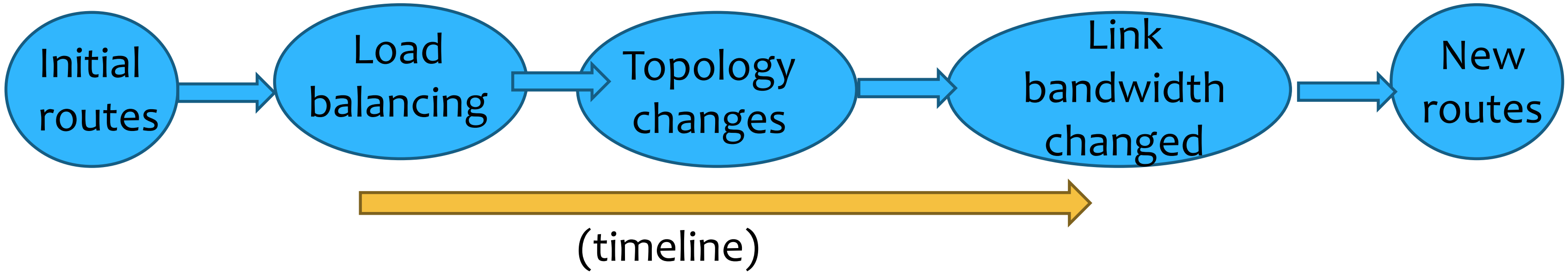
Distributed Control Plane



- Data plane: multiple domains of switches
- Control plane: the centralized control, a few controllers, running multiple network services (functions)
- Benefits of DCP: large scale; protecting domain privacy
- SDN Programming
  - Write service logics as running code at control plane
  - Write the forwarding logics to the data plane
- Work with Boyang Zhou, Chunming Wu, Ming Jiang,

Programming DCP

* **Handling Events**
  * **Internal:** by itself, e.g. timeout, link congestion;
  * **External:** by operator, e.g. readjusting the link metrics.
* **Update states in the distributed manner at different switches**
  * control states at the control plane
  * forwarding states at the data plane



States examples, FIB, ports, packet scheduling, queues…

Problems

Transient State

* **Inconsistent view of current control or forwarding states**
* Caused by different delays, losses when updating the states
* Lead to losses of in-flight packets (routing loop, black hole, misfunction)

Generic for different services (e.g., routing and firewall)

* Each needs to dealing with it, increases the complexities in developing a service in DCP (code, programmers)
* Duplicate efforts by multiple services in solving the problem, each works on own control states
* Delayed reaction to network dynamics
  * when one service forces the network conditions to change, other services are not able to learn until a performance bottleneck occurs

Research Goal and Approach

Goal: Reduce the complexity for network programing tasks involving DCP

* Offer common interfaces for the complex, yet-similar tasks in dealing with inconsistence in the states, reduce network holding time

Our approach: supervision layer -- proGRAmming Control layer

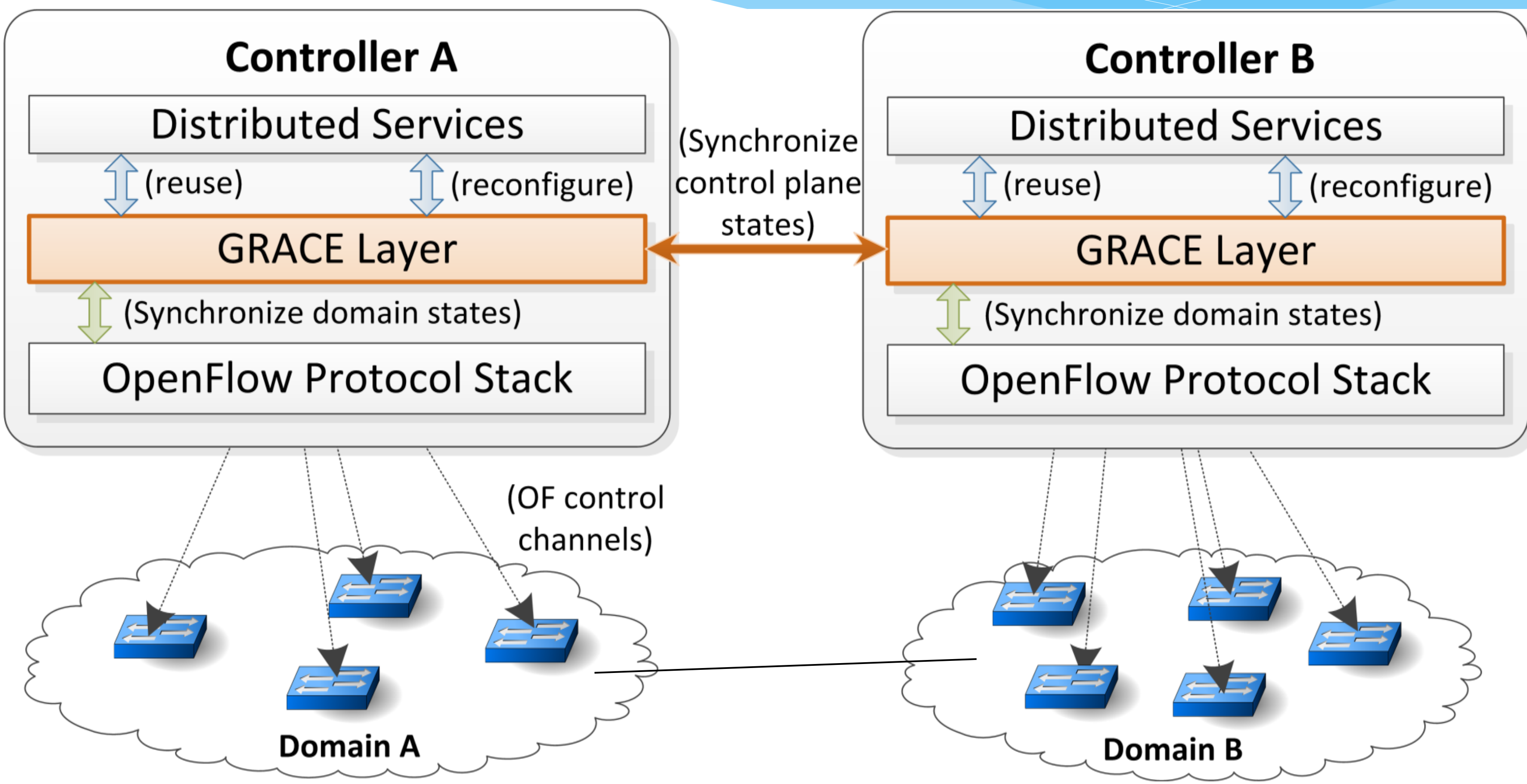
* Identify service components, sharable common control states; and provide access control (Reusability of control states)
* Safely update the current forwarding states to the new states, without interrupting the data flows (Re-configurability of data plane states)

proGRAMming Control (GRACE) layer

API guarantees that a service sees consistent data plane states

* DHT and two access models
  * Control states are organized using Chord (a DHT)
  * Active control state reuse
    * proactively pull to synchronize all the states
  * Passive control state reuse
    * passively receive only the changes
* Lossless reconfiguration protocol
  * Three phases of lock steps in updating forwarding rules
  * Buffer in-flight data packets and flow states, and restore

proGRAMming Control (GRACE) layer

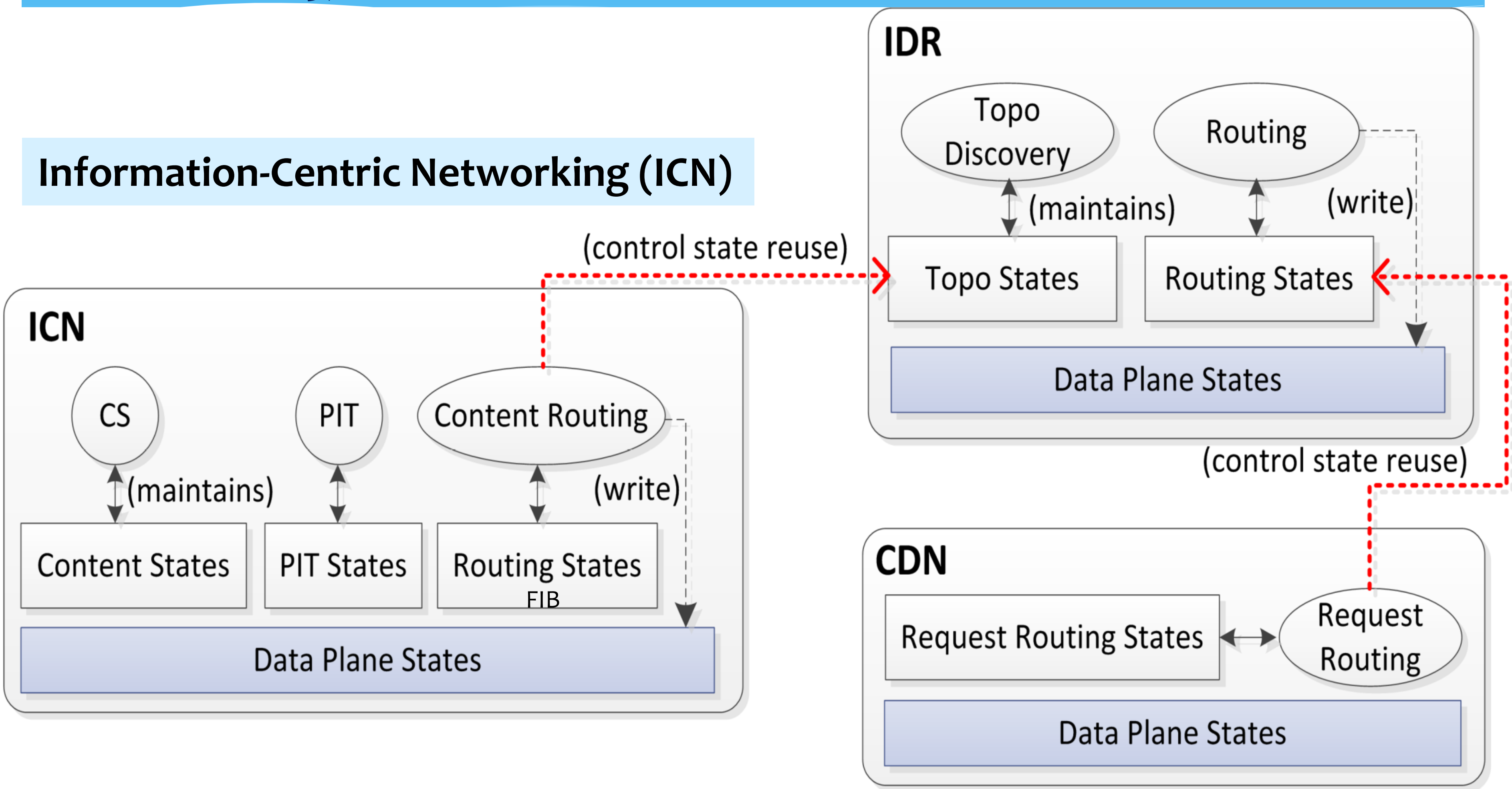


Case Analysis

Evaluated in NS3, ndnSim and PlanetLab

Inter-Domain Routing (IDR) service

Information-Centric Networking (ICN)



Content Distribution Networks (CDN)

Related Research

Other work in software defined networking and network virtualization

* Handle dynamic data traffic with uncertainty in the data plane
  * Reduce the overhead in control channel and delay in reaction
* Network programming language: higher level network function abstraction

* Participated in GENI (Global Environment for Network Innovations)

Data-Rich Underwater Networks

* Mobile ad hoc, delay tolerant, wireless networks
* Underwater acomm networks : mobility, DTN routing, map portal

* Trading Computing/Storage/Mobility for Communication
* Named data, searchable and retrievable (Information Centric Networking) for data-rich underwater environment monitoring and information system

Why Software Defined Networking (SDN) for Underwater Comm and Net

- Resource sharing , interoperability
- Evolving PHY, NET, APPl -- double edge
  - Abstraction and interfacing with lower and upper layers
  - Open, standardizing
- Support network experiment and evolution
- Simplify network management
  - Centralized management for recourses, abstraction and programmable data plane, reduced complexity in error checking and maintenance
  - Improve network performance, e.g., energy efficiency

SDN – Challenges and Current UW Acomm and Network 1

- Applications and network architectures
  - AUVs/gliders, sea floor or 3D sensor net, mobile array
  - Static (hierarchical), single hop, multi hop, mobile, data mule
  - Data collection, command and control
  - Multiple roles: sensing(monitoring), in-situ data processing, communicating, forwarding, moving
  - Current SDN: routing choices, performance and priority parameters, commending multiple platforms (UWSN, gliders), etc.
- Switching fabric
  - Different "switch", maybe multiple radio fronts
  - Current SDN: reconfigurable radios/modems and MAC parameters, shared, open architecture (modems)

SDN – Challenges and Current UW Acomm and Network 2

- Data plane vs control plane, and new components
  - Mesh sensor networks, gliders/AUVs, data mules/DTN
  - Each device multiple roles: generating data and networking, networking only
  - Static, mobile, or coordinated/planned mobility
  - In-network processing
  - Management tools (resources, power, navigation, etc)
  - Current SDN: in-network processing in data plane, adaptive protocol stack, control plane, application plane

SDN – Challenges and Current UW Acomm and Network 3

* Resource sharing (concurrent experimentation), virtualization, multiple radio fronts
  * Testbed, multiple applications/experiments shared use
  * Current SDN: wireless hypervisor, NFV
* Distributed systems under harsh network conditions
  * Multiple controllers, distributed, connected, latency, reliability, limited bandwidth
  * High programming needs for the increasing number of applications/ services, trained in multiple disciplines
* E2E secure channel vs data-centric security

Thank you!

Questions?