ComputerScience

Boston University

Network Functions Virtualization using ProtoRINA

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What is RINA? [1][2]

- RINA: Recursive InterNetwork Architecture
- A clean-slate network architecture that overcomes inherent weaknesses of the current Internet, e.g. security, mobility support
- Based on the fundamental principle that *networking is Inter-Process Communication (IPC) and only IPC*
- Distributed IPC Facility (DIF): a collection of distributed IPC processes with shared states. They provide communication service to application processes over a certain scope (i.e., range of operation)
- Distributed Application Facility (DAF): a set of application processes cooperating to perform a certain function. The function can be a communication service, weather forecast, genomics, *etc*.
- Two design principles: (i) divide and conquer (recursion), and (ii) separation of mechanisms and policies

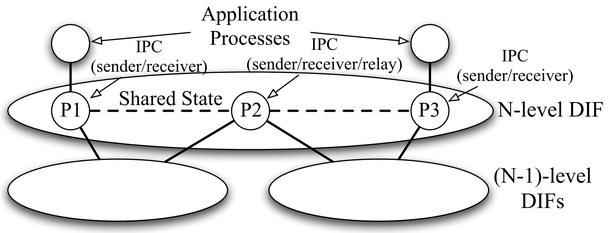

Fig 1: RINA overview

ProtoRINA: A RINA Prototype [3]

- ProtoRINA is Boston University's user-space prototype of RINA
- Enabling the programming of recursive-networking policies
- Experimental tool for developing (non-IP based) user and management applications
- Teaching tool for networking and distributed systems classes
- Version 1.0 released on October 2013; around 55,000 lines of Java code following the RINA specifications of January 2013
- Disclaimer: The current version is not a complete implementation of RINA and we continue to modify and add elements

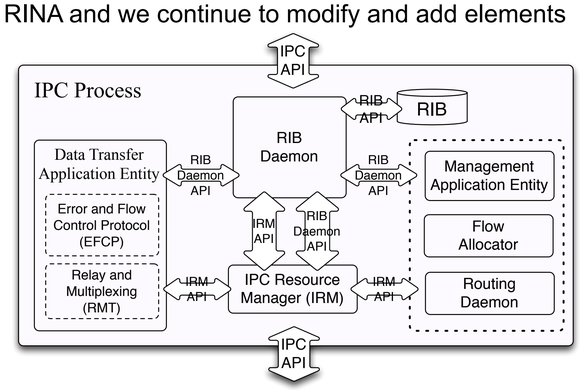

Fig 2: IPC components and RINA APIs

Network Functions Virtualization [4]

- Network Functions Virtualization (NFV) aims to implement network functions (e.g. firewalling, NAT, intrusion detection systems) as software instead of dedicated physical devices (middleboxes)
- NFV decouples the network functions from proprietary devices, and it is designed to virtualize and consolidate network functions onto industry standard high volume servers, switches and storage
- Advantages of NFV include reducing equipment cost, speeding up new service deployment, achieving high service performance, *etc*.

RINA-based NFV

- NFV is inherently supported by RINA. For example, RINA supports Virtual Network as a Service by dynamic Layer (DIF) formation [5], where a DIF can be viewed as a virtual private transport network
- A Virtual Network Function (VNF) can be easily added on existing networks, and can be hosted in a different location (e.g. datacenter network)
- Every application process in a DAF can provide a VNF, and applications providing VNFs, publish their service by registering with a RINA directory service

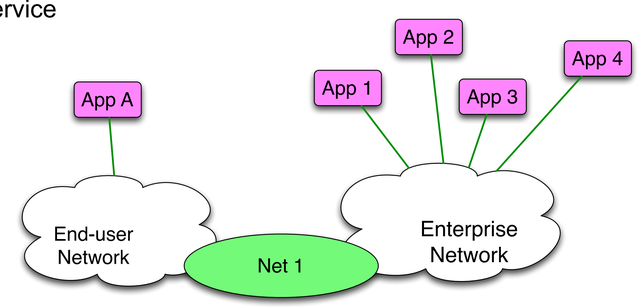

Fig 3: Before VNF is added, end-user and enterprise networks are connected by a transit network, and different applications are running on each network

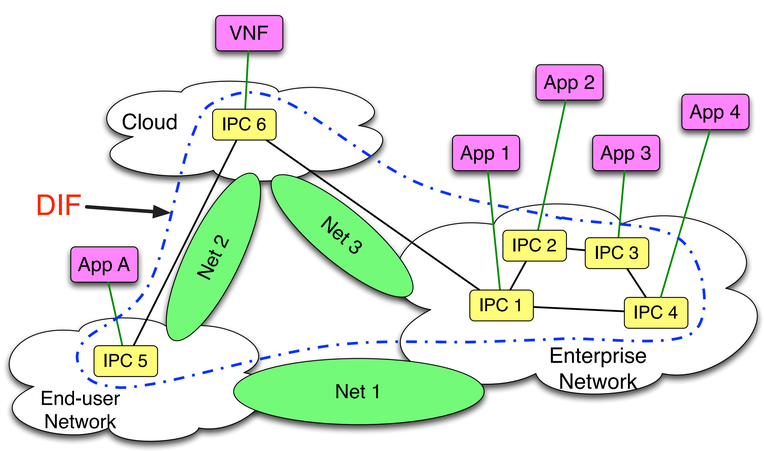

Fig 4: A virtual network function (VNF) application is running on the cloud. Enterprise applications, end-user application and VNF application communicate using a common underlying DIF which spans multiple networks

Use Case: Firewalling as a Service

- Firewalling improves network security by controlling the incoming and outgoing network traffic, and protects the internal private network from exposure to the public
- As shown in Figure 4, application **VNF** is a firewalling process registered as the firewall for the enterprise network. **VNF** enrolls a foreign user application **App A** before it can access application **App 1 (**or other applications running on the enterprise network**)**. After enrollment, **IPC 5** is created to join the DIF via **IPC 6**. Then **App A** is able to communicate with **App 1** through the underlying DIF, and the connection between **App A** and **App 1** is mapped to a flow (**IPC 5 – IPC 6 – IPC 1**) in the underlying DIF
- Mechanisms and policies that support Firewalling as a Service:
  - RINA directory service
  - Authentication (DAF and DIF)
  - DIF neighbor discovery
  - Access control (enforced by underlying IPC processes)

Experiments over GENI

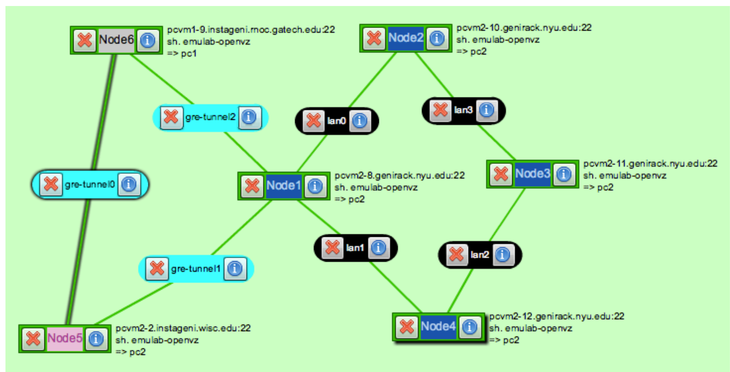

Fig 5: VMs from three instaGENI aggregates (NYU, Gatech and Wisconsin). Enterprise network is running on NYU aggregate, end-user network is running on Wisconsin aggregate, and datacenter network is running on Gatech aggregate

References

[1] John Day, Ibrahim Matta and Karim Mattar. "Networking is IPC: A Guiding Principle to a Better Internet". In ReArch 2008.

[2] Boston University RINA Lab. http://csr.bu.edu/rina.

[3] Yuefeng Wang, Ibrahim Matta, Flavio Esposito and John Day. "Introducing ProtoRINA: A Prototype for Programming Recursive-Networking Policies." In ACM SIGCOMM CCR, July, 2014.

[4] ETSI. "Network Functions Virtualization – Introductory White Paper", October 2012.

[5] Flavio Esposito, Yuefeng Wang, Ibrahim Matta, and John Day. "Dynamic Layer Instantiation as a Service". Demo in NSDI 2013.