IPOP: P2P Overlay Network for Cloud Computing Research

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Background and Motivations

- Virtual Private Networks (VPNs) enforce privacy and authentication in IP communications
- Privacy desirable for end-to-end communication among users
- Virtual network desirable to connect multiple cloud instances
- Challenges in existing VPNs:
  - Configuration is difficult, error-prone
  - Node mobility and elasticity (e.g. phones, cloud VMs)
  - Performance overhead of centralized server gateways
- IPOP: user-defined, easy to configure, self-managed end-to-end VPNs connecting nodes through P2P links

IPOP Core Features

- User-level: works on a variety of operating systems and devices
  - Linux (Desktop/laptop, Android, OpenWRT), Windows
- Peer-to-peer links with integrated NAT traversal
- IPv4 and IPv6 virtual networking – supports existing applications
- User-friendly social network based peer discovery
- User-transparent certificate exchange and network configuration
- Build upon standards for messaging and NAT traversal
  - XMPP, STUN, TURN
- Modular and extensible

Use Cases and Users

- Virtual clusters, platforms across multiple clouds
  - ConPaaS, Kangaroo (PaaS)
- Social networking infrastructures and applications
  - SocialVPN (P2P VPN), Litter (P2P microblogging app)
  - Mobile devices; offloading (NSF EAGER/NSF-C)
- Collaborative environments for e-Science / PRAGMA
  - GLEON lake ecology modeling expedition (distributed HTCondor cluster)
  - Rocks (PRAGMA Cloud)
- Disaster management (Navy/DoD)

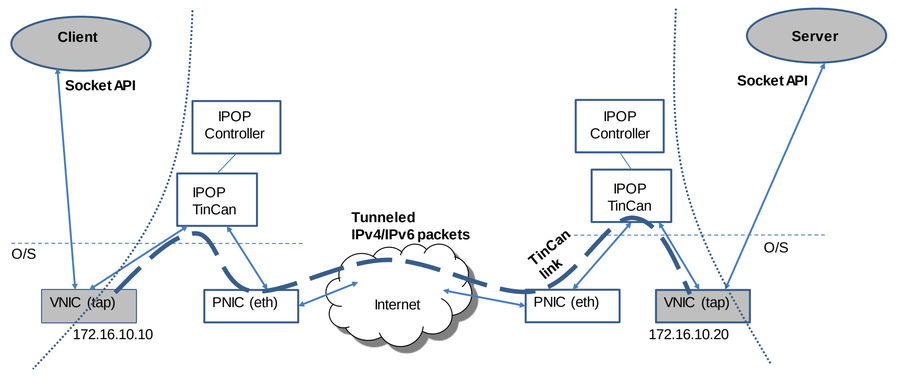
Software: Status and Future Work

- Major software design re-factoring; releases: 14.01, 14.07, 15.01
  - Software reuse (Google libjingle), standards
  - Separation of concerns: datapath/control modules
  - Extensibility to support different overlay topologies
  - Support for mobile devices (Android), embedded (Raspberry Pi, Intel Edison), wireless routers (OpenWRT)
  - Multi-hop overlay routing, dynamic source routing
  - Switch mode (Layer 2, ARP) – multicast
  - adminGroupVPN: multi-user chat rooms
  - Ganglia monitoring module
- Ongoing/future work:
  - Support for DHCP, DNS
  - OpenFlow virtual switches for packet capture/injection
  - Bootstrapping: NAT traversal through social peers

Architecture Overview

Peer-to-peer "TinCan" links:

- Core abstraction – IPOP tunnels packets (IPv4, IPv6) over private TinCan links
- Transparent to applications – no modifications necessary to client/server



Major modules:

- IPOP-TinCan: sets up TinCan links; tunnels, forwards packets
- Controller: manages TinCan link start/trim; maps IP addresses; overlay routing
- IPOP-Tap: interfaces with O/S for packet capture/injection

Controller/TinCan API:

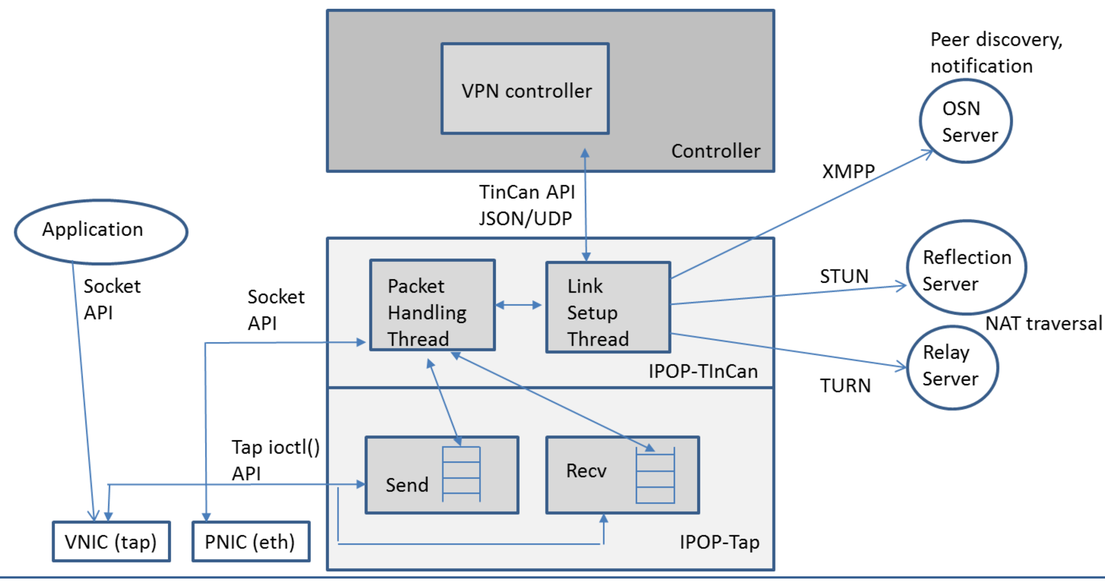
- Different VPNs for different use cases (SocialVPN, GroupVPN)

Social Network Bindings and Peer Discovery:

- XMPP Protocol – support for existing OSNs and open-source (ejabberd)

NAT Traversal:

- STUN (UDP hole-punching), TURN (relay through public node)



SocialVPN and GroupVPN

Two IPOP controllers maintained by the project

SocialVPN

SocialVPN:

- Links social users to their friends
- Use cases: remote desktop, streaming, gaming, new social apps
- Individual user-centric: each user manages their own links
- Technical challenge – managing address allocation
- IPv4 addresses are dynamically assigned/translated

GroupVPN

GroupVPN:

- Links multiple devices together in clusters
- Use cases: inter-cloud, ad-hoc virtual clusters
- Per-group: devices belonging to a group connected all-to-all
- Addresses are not translated

This material is based upon work supported in part by the National Science Foundation under Grant No. 1339737. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.