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Software Defined Networking (SDN) in Next Generation Telecom Infrastructure: Some Quick Wins and the Road Ahead

Never Stand Still

School of Electrical Engineering & Telecommunications



Outline

- SDN: what and why?
- Status of SDN
 - Where is it doing well – why?
 - What are the pain points?
- Quick-win use-cases of SDN:
 - Home network: new capabilities for consumers
 - Enterprise/carrier network: video telemetry and management
 - Interconnects: IXP and cloud-connect
- What next for SDN?
 - Security as the killer use-case?

SDN: What and Why

- Basics: separate data plane from control/mgmt plane
 - Control and mgmt software decoupled from switch hardware
 - Can customize/adapt software without waiting for switch vendor
- Birth of Openflow:
 - Abstraction of data-plane: match + action
 - Centralize intelligence and do away with distributed state mgmt
 - Standardize interaction between control and data planes: OF proto
- Implications:
 - Control/management software works across any vendor hardware!
 - Can define and build arbitrary algorithms for switching, routing, load balancing, failure recovery, security, ...

How is SDN Doing?

- Successes:
 - Data centers: Nicira / VMware
 - Google (B4), Facebook, Microsoft
 - Carriers: AT&T (CORD), Telstra (Pacnet)
 - Enterprises: ???
- Barriers:
 - Business cases still emerging: automation?
 - Complexity due to fragmented eco-system:
 - Hardware: Pica8, Noviflow, Corsa, Allied Telesys, ...
 - Controllers: Ryu, ONOS, ODL
 - Southbound protocols: Openflow, Netconf, ...
 - Software applications: “App store” ? Support model ?
 - Skills: software life-cycle, support, open-source, ...
 - Fear factor: risks inherent in radical change

We need some Quick Wins!

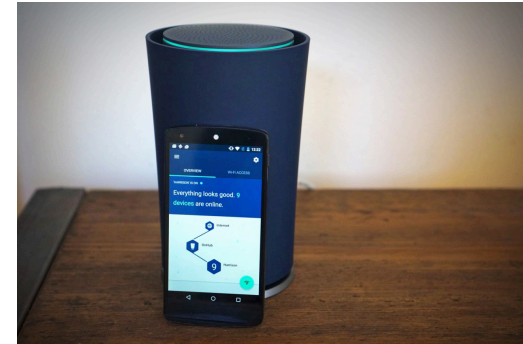
- Localized solutions that do not require network overhaul
- Home network [**Seer**]:
 - Increasingly complex but no innovation in past 20 years!
 - SDN can provide device visibility, quota management, parental control, ...
- Enterprise/carrier network [**TeleScope**]:
 - Poor visibility into video streams
 - SDN can provide low-cost scalable monitoring and control of video
- Inter-connect networks [**CaSToR**]:
 - Inflexible/dumb interconnects between domains and/or cloud
 - SDN can provide flexible inter-connects with smart telemetry, security, ...
- **Security**: an important but unmet gap?

Home Networking [Seer]

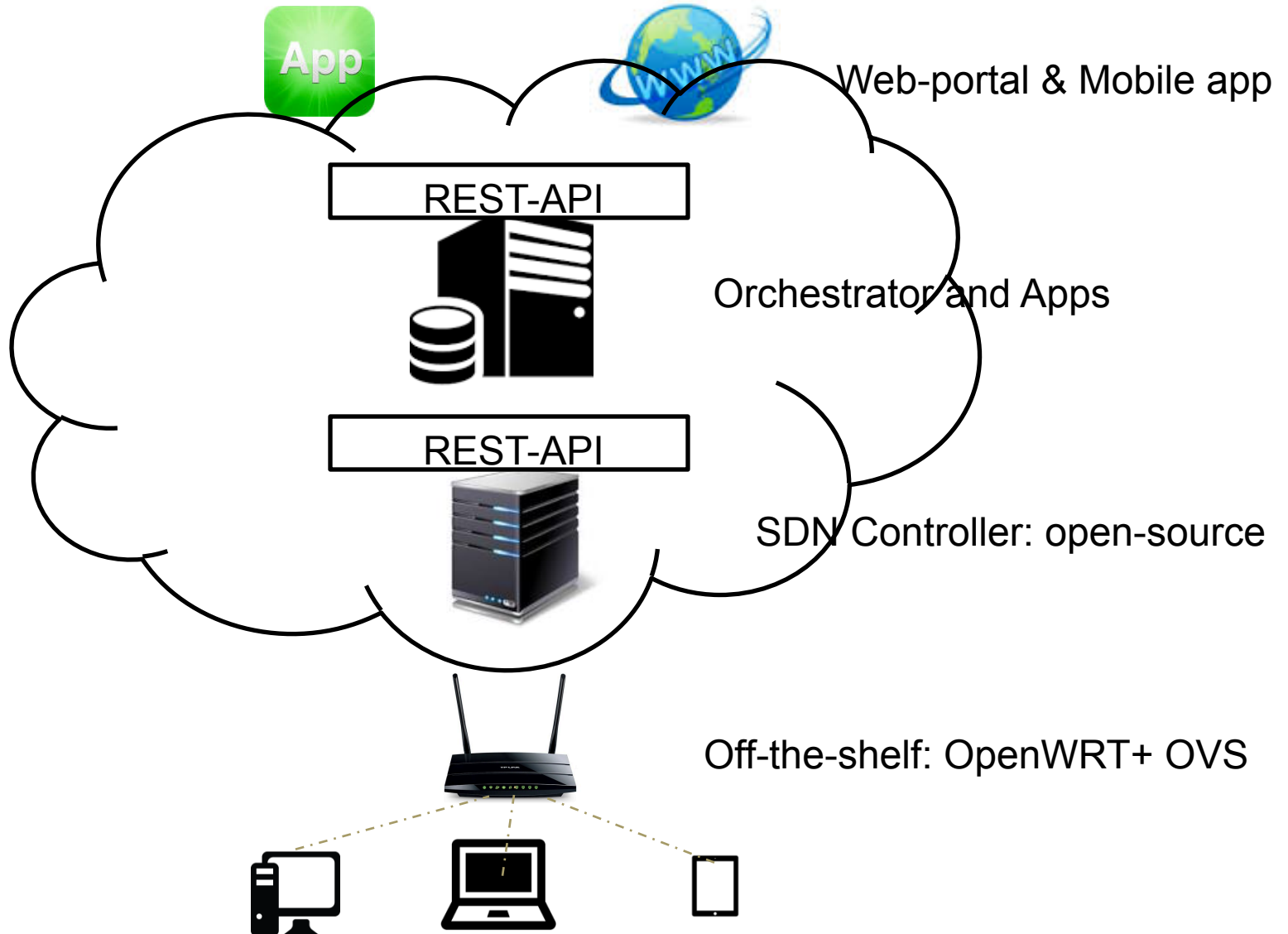
- No innovation in home networks for long time, but home networks are growing!
- **Consumer**: Increasingly complex home network with many devices and multiple users
 - No visibility into usage of bandwidth and quota
 - No control on online (child) safety
 - No protections against (smart-home) attacks
- **ISP**: Stagnating revenue streams
 - Low-margin competitive business
 - No visibility into consumer home network

Current Solutions

- Smart home-routers:
 - Google onhub
 - Luma, Chime, KoalaSafe
 - Coju, Dojo, Almond
 - Disney Circle, Sense
- Drawbacks:
 - Custom hardware (cost?)
 - Embedded software (upgrade?)
 - Direct sale to consumer (scale?)



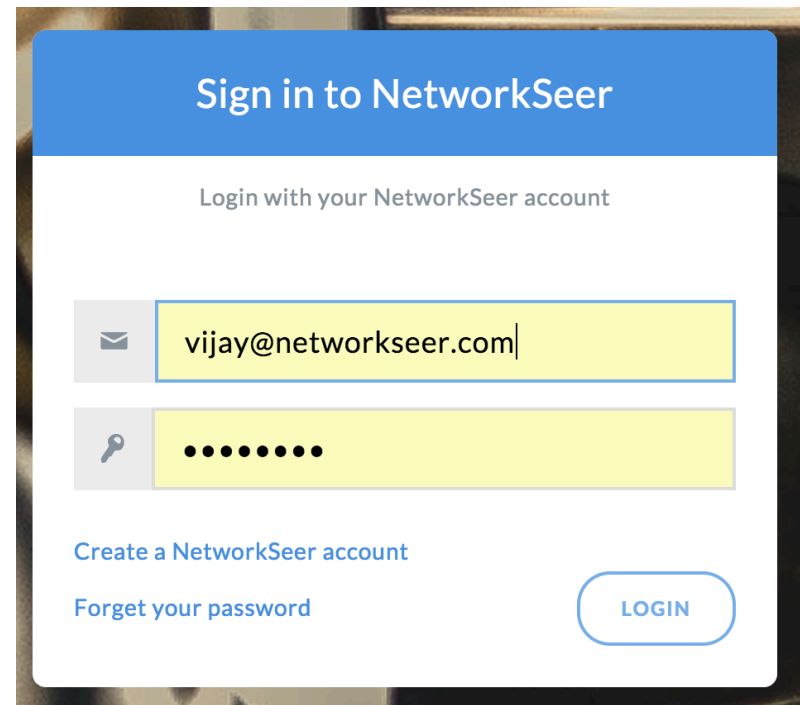
SDN based "Seer"



Seer: SDN Based Home Networking

- Architecture:
 - Home gateway: TP-LINK AC1750 (off-the-shelf)
 - Firmware: OpenWRT and OVS (open-source)
 - Controller: FloodLight (open-source)
 - Applications: Ruby-on-rails + postgresSQL
 - Portal: ReactJS + Rubix

<http://www.networkseer.com/>



The image shows a login form for NetworkSeer. The form has a blue header with the text "Sign in to NetworkSeer". Below the header, it says "Login with your NetworkSeer account". There are two input fields: one for the email address, which contains "vijay@networkseer.com", and one for the password, which is masked with dots. Below the input fields, there are two links: "Create a NetworkSeer account" and "Forget your password". A blue "LOGIN" button is located at the bottom right of the form.

Seer: Device Visibility

REFRESH

HIDE INACTIVE DEVICES

Search:

Device Name	User	Mac Address	Last Seen	Customised Colour
Apple-TVv1	default	18:ee:69:1f:fa:41	1 minutes ago	darkgoldenrod
Blanca-iPhone	blanca	60:92:17:66:d9:3e	1 minutes ago	mediumorchid
iPad-Red	kiran	10:40:f3:dd:87:7a	1 minutes ago	red
iPad-White	blanca	74:81:14:4a:bc:52	15 minutes ago	pink
Printer-epson	default	64:eb:8c:77:31:8f	1 minutes ago	springgreen

Device Name User Mac Address Last Seen Customised Colour

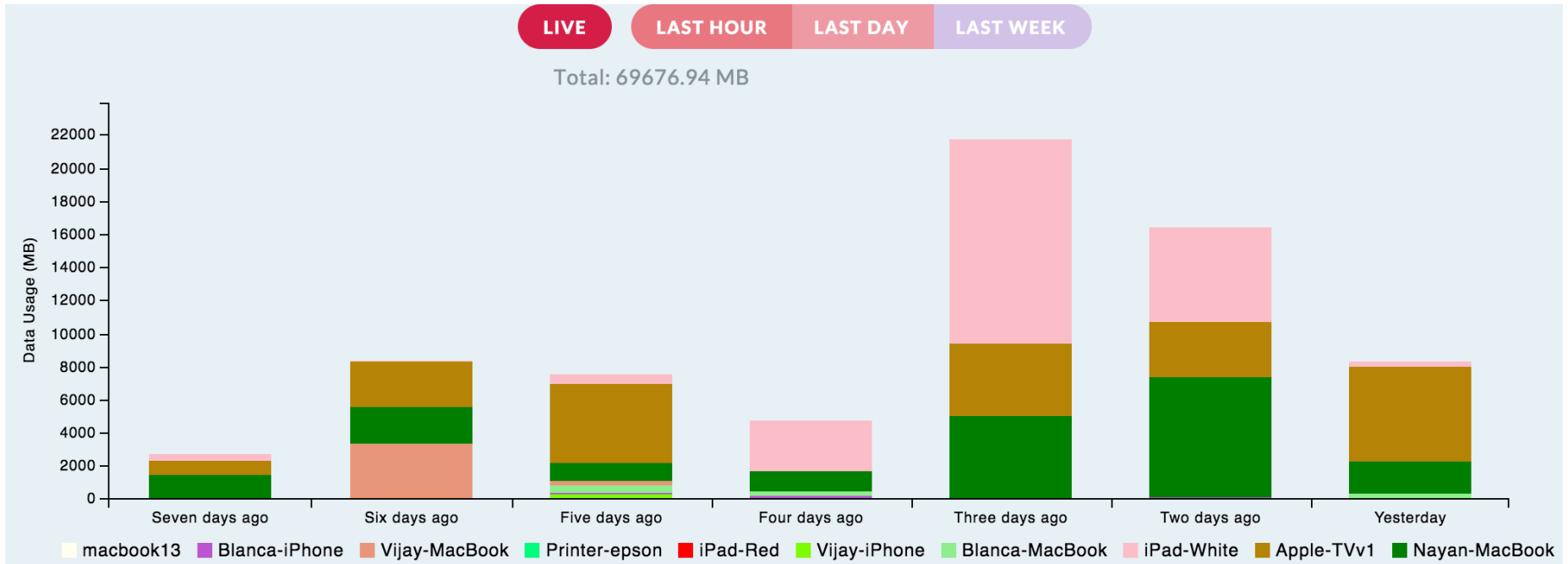
Showing 1 to 5 of 5 entries

PREVIOUS

1

NEXT

Seer: Data Usage



Seer: Quota Per-Device

REFRESH

Billing cycle starts at 2016-11-01

73.34 out of 10000 GB has been consumed

User	Consumption Limit (GB)	Current Consumption(GB)
blanca	unlimited	23.38
default	unlimited	23.93
kiran	20.00	0.06
nayan	80.00	22.18
vijay	unlimited	3.79

User	Consumption Limit (GB)	Current Consumption(GB)
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Seer: Parental Controls

Device

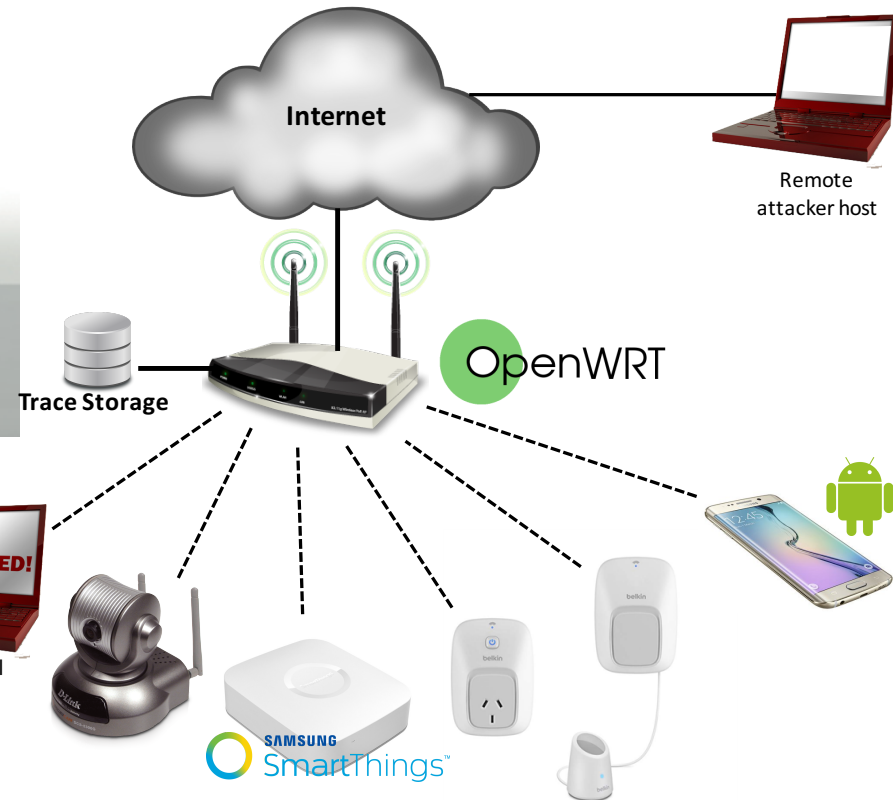
WinstonsiPhone

APPLY CHANGES

App Filter Time Filter Content Filter

 TWITTER	<input checked="" type="checkbox"/>
 FACEBOOK	<input type="checkbox"/>
 GOOGLE+	<input type="checkbox"/>
 LINKEDIN	<input checked="" type="checkbox"/>
 INSTAGRAM	<input checked="" type="checkbox"/>

Seer: IoT Visibility and Security



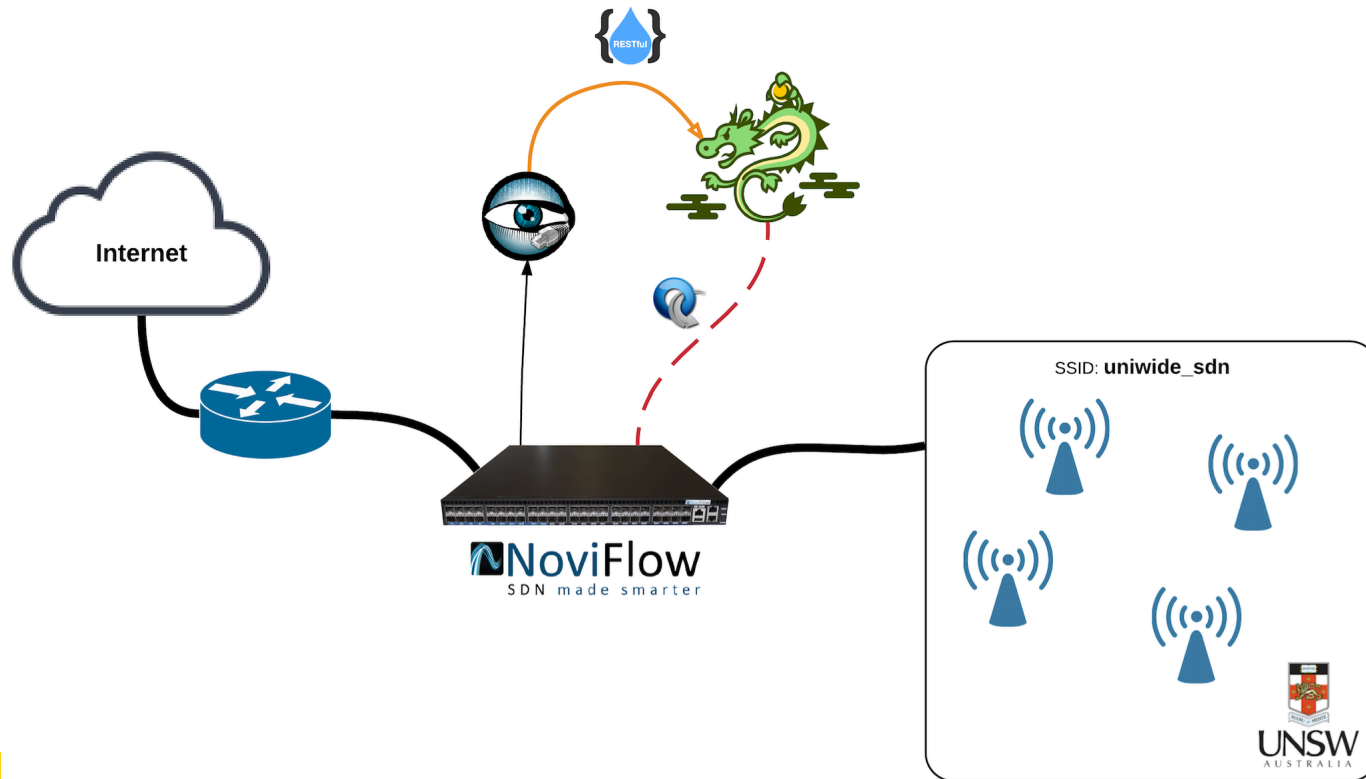
- IoT detection and traffic profiles
 - Anomalous behavior
 - Low-cost, scalable
 - Can adapt to evolving threat

TeleScope: Video Telemetry

- **Video traffic** growing exponentially
 - Netflix, Youtube, iView, Stan, etc.: >50% of network traffic
 - Augmented reality / virtual reality likely to grow dramatically
 - Adaptive bit-rate: expands to fill space available!
- **Challenge:**
 - “Understand” video traffic in the network
 - How many flows? What resolutions?
 - “Manage” video traffic while being aware of user-experience
- **Current solutions:**
 - Sampling (sFlow): trade-off accuracy / cpu-load on switch
 - Middle-boxes / “appliances”: special-purpose, expensive!
- **SDN:** flexible (flow-level) telemetry under software control

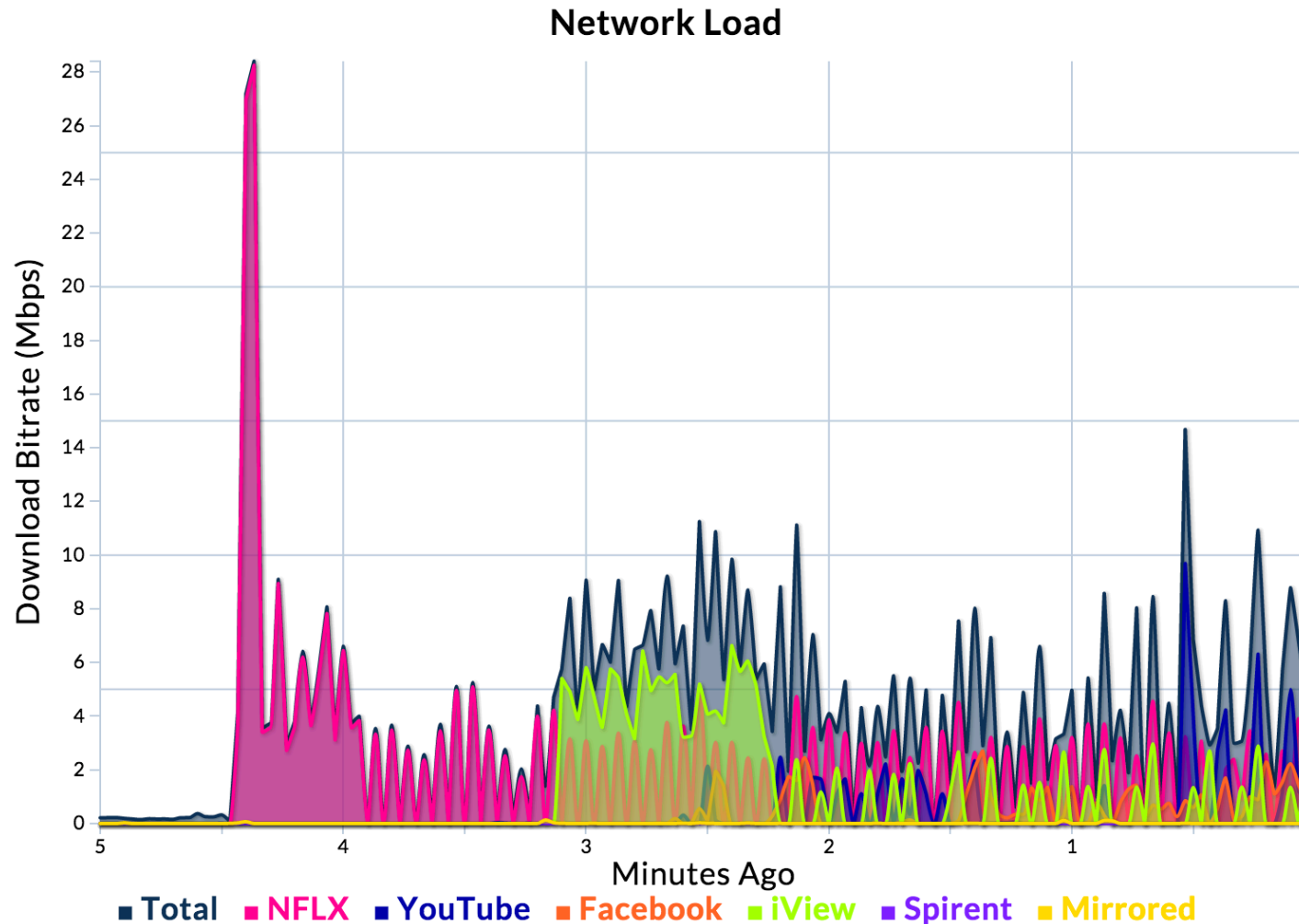
TeleScope Architecture

- Bump-in-the-wire:
 - SDN switch + Bro analyzer + Ryu SDN App
 - Dynamically manipulate flow-table rules:
 - mirror first few pkts of flow; watch flow stats thereafter



Real-time Traffic Visibility

- Video flow properties (src/dst, web/mobile, b/w, quality)
 - Analytics on video profile to identify resolution/quality



TeleScope: Benefits

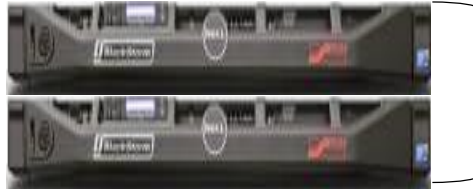
- Works on UNSW campus experimental SDN-WiFi network
- Operational on UNSW dorm wired network
 - Serving few hundred students
- Scale-tested to 32k flows in lab
- “Safe” solution:
 - Can work as “bump-in-wire” or with mirror traffic
 - Data-plane resilient to controller failures
 - Fraction of cost of “middlebox” solutions
- **Looking for enterprises/operators to do trials!**

CaSToR: Inter-Connects

- Internet Exchange Point (IXP) = Route-Servers + L2-data-plane:
 - Hygiene: Ether-types, ARP broadcasts, multicasts, one MAC per-port, ...
 - Free-riding: no enforcement of policy
 - Static provisioning (and pricing), poor telemetry
- SDN/OpenFlow presents an opportunity:
 - Leverage IXP's natural separation of control and data plane
 - But enforce tighter coupling between the two!
 - Replace data-plane layer-2 switch with OF switch (similar cost)
 - Augment control-plane with ONOS app (CaSToR)

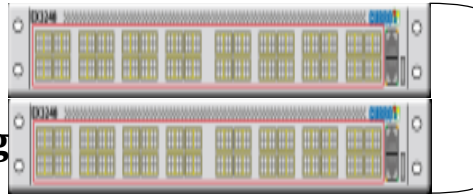
CaSToR: Architecture

Management plane: web-server for GUI provisioning, policy config, telemetry APIs, billing integration



**Commodity servers
ONOS Controller,
CaSToR Application,
Web-server**

Control plane: runs BGP peering, pushes policies into data-plane, provides features like monitoring



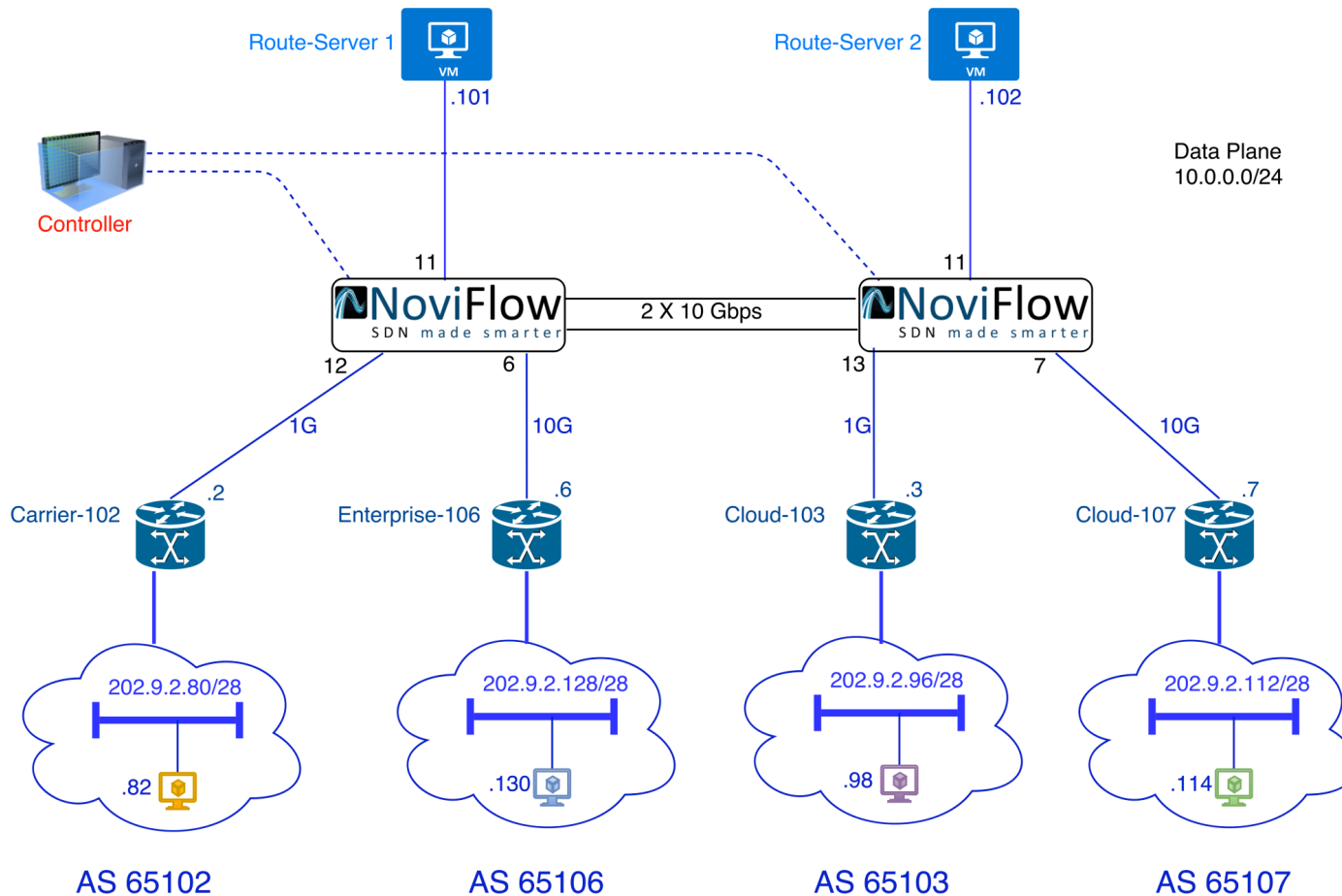
Commodity spine switches

Data plane: OF1.3 leaf switches with customer-facing ports



**OF leaf switches
(NoviSwitch)**

CaSToR Example Setup



CaSToR GUI

The screenshot shows the CaSToR GUI interface. The top navigation bar includes the CaSToR logo, a menu icon, a user profile icon, a lock icon, a search icon, a share icon, a notification bell with '11' alerts, and a mobile menu icon. The left sidebar contains 'Main Navigation' (Dashboard, Add a Customer, Route Servers) and 'Components' (Elements, Forms, Charts, Tables). The main content area is titled 'Summary of Customers' and features a 'Synchronize' button. Below this is a section for 'Added Peers' with a search bar and a table. The table has columns for Customer Name, IP Address, Location, Status, and Action. It displays four entries: studio-2, studio-3, enterprise-6, and cloud-7. A footer shows 'Showing 1 to 4 of 4 entries' and pagination controls (Previous, 1, Next). The copyright notice '© 2016 - Castor' is at the bottom left.

Summary of Customers

Synchronize

Added Peers

Show 10 entries Search:

Customer Name	IP Address	Location	Status	Action
studio-2	10.0.0.2	of:0000000000000002/12	active	Delete
studio-3	10.0.0.3	of:0000000000000004/13	active	Delete
enterprise-6	10.0.0.6	of:0000000000000002/6	active	Delete
cloud-7	10.0.0.7	of:0000000000000004/7	active	Delete

Showing 1 to 4 of 4 entries Previous 1 Next

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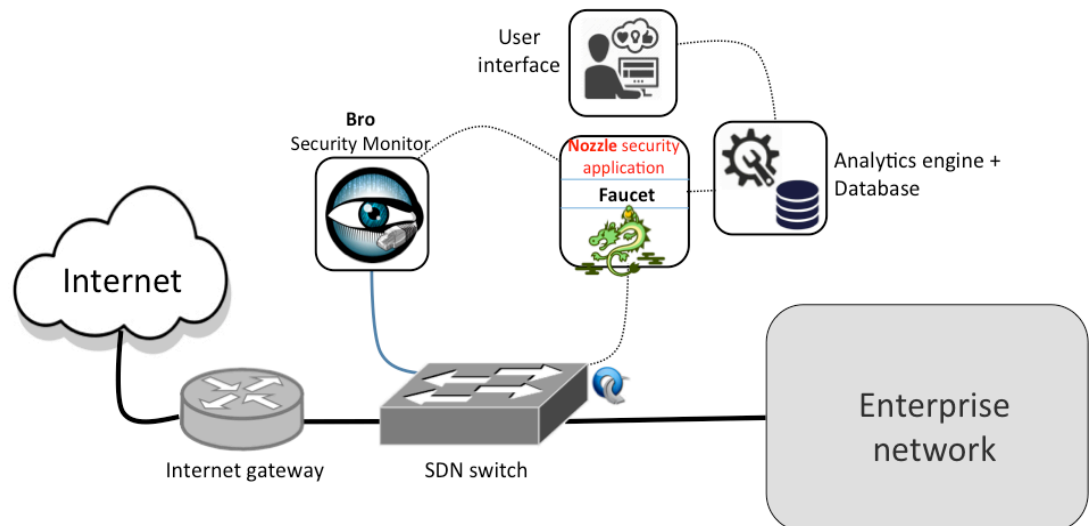
CaSToR Benefits and Roadmap

- Replicates today's IXP architecture: can use legacy border router
- Enforces fabric hygiene: ARPs unicast not broadcast
- Web-based (ReactJS) portal for easy provisioning (via REST APIs)
- Platform for innovations:
 - Granular telemetry – instant visualisation of inter-AS traffic (InfluxDB+Grafana)
 - Security policy enforcement
 - Automated provisioning and elastic scaling (pricing) of cloud-connects
- Status and future plans:
 - Operational at 8 sites across Australia; peering with US/Europe
 - CaSToR is standard in next release of ONOS
- Looking for IXPs / Interconnect providers who are keen for trials!

Security: Killer Use-Case for SDN?

- Escalation in cyber-attacks:
 - Home devices being used for reflection attacks
 - Enterprises lacking skills to configure and manage security
 - Carriers have opportunity to offer managed security services
 - Internet exchanges can offer value-add security services
 - Geo-blocking; source-address filtering
 - Perimeter defense does not suffice
 - Need continuous monitoring of internal network traffic

- SDN offers tremendous opportunity:
 - Can adapt granularity of monitoring dynamically
 - Can integrate various sources of intelligence (Radius, DHCP, DNS, ...)



Conclusions

- SDN has great intellectual appeal
 - Some wins: DC networks, large CP networks
 - But many pains: fragmentation, lack of skills
- “Easy” use-cases – localized solutions with clear benefits:
 - [Seer] SDN for the home: device visibility, quota, parental control, security
 - [TeleScope] Enterprise/carrier fine-grained visibility into video flows
 - [CaSToR] Flexible inter-connect with enhanced telemetry, security
- The road ahead:
 - Need more focus on development of skills and building community
 - ANZ-SDN Alliance: www.anzsdn.net
 - Encourage carriers to “get hands dirty” and “experiment”
 - Encourage researchers to develop and demonstrate prototypes