Management and Operations of Networks, Services, and Systems

Concept overview sprint

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Management vs. Operations

- Management:
  - conceptual, high-level dimensions to keep network running smoothly
  - ‘smoothly’: QoE, reliability, security, etc.
  - manage monitoring, configurations, performance, faults, security, accounting, etc
- Operations:
  - people, processes, and tools to make management happen
  - typically in the network operations center

Dimensions of networking – packets

- Packet switch and forwarding, data plane – microseconds
  - Looks up rules – packet header, in/out interfaces, timeslot, etc
- Switching control (aka ‘network functions’ – routing, QoS, firewall, etc) – control plane – miliseconds
  - Reacts to changes (interfaces, links, etc); control is centralized or distributed (neighboring routers)
  - Update switching rules
- Network Services (DHCP, DNS, Radius, LDAP, etc) – miliseconds
  - Provide mapping – MAC-IP, IP-Domain name, accounting, etc

Dimensions of networking – management

- Configuration
  - Provisioning, software updates, structural changes, minor configuration changes
- Performance assessment
- Accountability
- Fault management
- Security

Changing network topologies

- Spanning Tree: focus on Ethernet reliability while avoiding loops

Changing network topologies

- Spanning Tree: focus on Ethernet reliability while avoiding loops
- Fat tree: focus on bandwidth between nodes
- Clos network, crossbar switch, multistage
  - Strict-sense nonblocking: unused input => unused output [ok]
  - Rearrangeably nonblocking: need to rearrange the connections between middle switches
- Traffic demands:
  - North-south (computer to Internet), typical enterprise – spanning tree
  - East-west (computer to computer), data center – fat tree

Services and systems

- Traditional network-based services
  - Mail, web, storage (NAS/SAN), database, etc.
- More complex services aka ‘systems´
  - Three tier applications (database backends, user-facing applications, application)
  - Micro-services, REST APIs, publish-subscrive
  - Big data – mongoDB, Hadoop, ELK
- Moving to virtual servers (KVM, etc) and containers (docker, k8s)
- Require adequately provisioned network

Devops in the cloud

- Traditional release deployment:
  - Gather specifications, UML architecture diagrams, implement, test, deploy
  - silos: dev team => |fence| => ops team
  - dev not consider operational requirements
  - broken deployments, long feedback to dev

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- devops approach:
  - quick deployment cycle (agile, test-driven, sprints)
  - write code thinking about other phases (deployment, testing, etc)
  - build rather than buy
  - automate test and deployment – repeatable, predictable
  - embrace failure (aka fail fast, find errors/vulnerabilities and recover quickly)

Devops for networking?

- Cloud environment easier because it's virtual
- Network 'harder'
  - More physical limitations – cables, device access
  - Hard to control – heterogeneous device API
  - Complex – multiple protocols, topologies, etc
  - Hardware bundle – switching, routing, etc in same closed box
- If we can do this, then we have:
  - Quick deployment – provisioning, updates, new devices, disaster recovery
  - Predictable deployment – same code, same outputs – no typos or missing commands on the console
  - Fail fast – quick rollback to previous configuration or quickly fix errors and redeploy
  - Build rather than buy – and even when buying, automating the 20% of the tasks that we need but that the device does not automate

Moving towards devops for networking

- Virtual networks
  - Connect remote devices as if in same L2/L3 network – vxlan, etc
- Software-defined networks
  - Well defined, open interface to upload switching rules
  - Flexible creation of networks, paths, etc across different devices
  - Many use SDN but don't actually need it – could use vlan and friends
- Network function virtualization
  - Enables running network functions (routing, etc) in generic hardware
  - Network functions in containers or VMs – quick, predictable deployment
  - x86-like devices popping up in the network, VMs connected by virtual switches
- Programmatic device interfaces
  - Richer interfaces for interacting programmatically with devices
- Anyone can write code

Key points for this sprint

- Management vs. operations
- Networking – packets
- Networking – management
- Chaning network topologies
- Services and systems
- Devops in the cloud
- Devops for networking?
- Moving towards devops for networking

Find out more about...

Management vs. Operations

- FCAPS
  - Find out the meaning of these letters.
- TMN/ITU-T, CMIP/ISO, SNMP&MIB/IETF
  - What are these standards? When were they developed?
- A bit of history (see sec. 1, 2): Cohen, H., & Kaufeld, J. C. (1978). UNIX time-sharing system: The network operations center system. *The Bell System Technical Journal*, *57*(6), 2289-2304.
  - What network is this NOC is for? How many bytes/s does this NOC handle?
  - What is the main task for the manager of this network?
  - What subsystems does the NOC have?
- NOC overview by Ayehu, http://ayehu.com/Network-Operations-Center-Best-Practices-Free-Ebook.pdf
  - Identify essential tools in the NOC
  - In this course we'll be focusing more on the tools than on the people and processes
- D.Kanwar and D. Raz , Book Chapter – The Future of Network Operations, 2016, CRC Press, ISBN 9781315365756
  - See fig. 9. ; notice 1) Vendor/Operator boundary missing on the left (devops) part; 2) no agile development in the operator part on the right (dev-for-ops). Why is that? (More on buying vs building later)

Find out more about...

Dimensions of networking – packets

- S. Das, G. Parulkar, N. McKeown, Unifying Packet and Circuit Switched Networks, doi: 10.1109/ GLOCOMW.2009.5360777
  - Which paradigm allows unifying packet and circuit switching?
- Switching control – https://doi.org/10.1145/1005686.1005723
  - Identify specific routing algorithms for different parts of the network (Internet, enterprise network, LAN)
  - Identify other applications of switching control beyond routing
- Services
  - Identify network services; what do they do and where are they located in the network?
- Other aspects of networking
  - Find other aspects of networking (e.g. framing) – and think about how they can be controlled or managed?

Find out more about...

Dimensions of networking – management

- FACPS
  - Is there a letter in FCAPS for monitorization? Where does it fit?
- Tools for FCAPS
  - What do you think is the management function with best tool support? And worst?
- What if scenarios
  - What would we need to have the network reconfigure automatically in case some failure or attack happens?

Find out more about...

Changing network topologies

- B4 (2013), Jupiter (2015), Orion (2021)
  - https://dl.acm.org/doi/abs/10.1145/2534169.2486019
  - https://dl.acm.org/citation.cfm?id=2787508
  - https://www.usenix.org/system/files/nsdi21-ferguson.pdf

➢What are B4, Jupiter, and Orion?

➢Find other topologies

Find out more about...

Services and systems

- Application architecture
  - What is a monolithic application? Why have complex applications moved to micro-service, REST-based architectures?

- Virtualization vs. containers
  - What's the difference? Come up with a list of advantages and disadvantages for each

Find out more about...

Devops in the cloud

- Traditional development delays implementation and spends longer in deriving requirements
  - Why?
  - Find examples of application domains where deployment is expensive
- Devops process
  - What is a sprint? And a product owner?
  - Find out the different steps in devops
- Devops tools
  - What's Jenkins and what do you do with it?
  - Organize your thoughts: releases, branches, commits?

Find out more about...

Devops for networking?

- Get an idea on ‘the ideal’ devops scenario for networking
  - Put in your own words what you would expect from devops for networking
  - ’Click on a button – and the network gets configured automatically’ is not enough – bring in more detail
  - For example, how do you tell the code what you need for the network? How many users and traffic, etc
- Going to need tools specifically for networking
  - Identify automation tools for devops
  - Identify automation tools for network/devops

Find out more about...

Moving towards devops for networking

- History of programmable networks
  - https://www.cs.princeton.edu/~jrex/papers/queue14.pdf
  - ➢ Identify relation between SDN and NFV
- Virtualization platforms for networking
  - ➢ Get a list of generic virtualization platforms and of projects that specifically developed for Networking and Service Providers
- SD-WAN
  - ➢ What's so special about Software-Defined Wide Area Networks?
  - ➢ Look for SD-WAN providers and identify what they really do