ONOS:
SDN OS for Service Provider Networks

- Scalability, High Availability & Performance
- Northbound & Southbound Abstractions
- Modularity
Service Provider Networks

- **WAN core backbone**
  - Multi-Protocol Label Switching (MPLS) with Traffic Engineering (TE)
  - 200-500 routers, 5-10K ports

- **Metro Networks**
  - Metro cores for access networks
  - 10-50K routers, 2-3M ports

- **Cellular Access Networks**
  - LTE for a metro area
  - 20-100K devices, 100K-100M ports

- **Wired access / aggregation**
  - Access network for homes; DSL/Cable
  - 10-50K devices, 100K-1M ports
Key Performance Requirements

High Throughput:
~500K-1M paths setups / second
~3-6M network state ops / second

High Volume:
~500GB-1TB of network state data

Difficult challenge!
Why Operating System?

- Provides useful services to applications
  - e.g. maintains connection persistence
- Provides framework for driving devices via arbitrary protocols
- Arbitrates shared network resources
- Provides abstractions to simplify resource sharing
  - application intent, network graph & device abstractions
- Isolates and protects resources, tenants & users
  - resource virtualization
- Comes with an SDK
  - APIs & docs, debugging, emulation, monitoring
Distributed Architecture

Apps

NB Core API

Distributed Core
(state management, notifications, high-availability & scale-out)

SB Core API

Adapters

Protocols

Adapters

Protocols

Adapters

Protocols

Adapters

Protocols
ONOS Evolution

● Written in Java

● First prototype
  o basic functionality, OpenFlow 1.0
  o scale-out, high-availability, northbound graph abstraction

● Second prototype
  o performance, scale improvements over first generation

● Both
  o prototype quality code
  o OpenFlow as the only southbound protocol
  o relied heavily on open-source off-the-shelf components
ONOS November Release

- Many improvements to distributed core
  - revamped NB & SB interfaces
  - revamped distributed state management
- New abstraction & API
  - application intents
- New & pluggable southbound
  - OpenFlow 1.3 support
  - plugin architecture for legacy protocols
- Improved GUI & CLI
- Modularity
  - revamped code-base for modularity
  - built atop OSGi container - Apache Karaf
ONOS November Release

Northbound Abstraction:
- network graph
- application intents

Core:
- distributed
- protocol independent

Southbound Abstraction:
- generalized OpenFlow
- pluggable & extensible

Northbound - Application Intent Framework
(policy enforcement, conflict resolution)

Distributed Core
(scalebility, availability, performance, persistence)

Southbound
(discover, observe, program, configure)

OpenFlow  NetConf  ...

Apps

[Diagram showing network components and arrows indicating direction of data flow]
Application Intent Framework

- Application specifies high-level intents; not low-level rules
  - focus on *what* should be done, rather than *how* it should be done
- Intents are compiled into actionable objectives which are installed into the environment
  - e.g. *HostToHostIntent* compiles into two *PathIntents*
- Resources required by objectives are then monitored
  - e.g. link vanishes, capacity or lambda becomes available
- Intent subsystem reacts by recompiling intent and re-installing revised objectives
Distributed Core

• Distributed state management framework
  ○ built for high-availability and scale-out

• Different types of state require different types of synchronization
  ○ fully replicated
  ○ master / slave replicated
  ○ partitioned / distributed

• Novel topology replication technique
  ○ *logical* clock in each instance timestamps events observed in underlying network
  ○ *logical* timestamps ensure state evolves in consistent and *ordered* fashion
  ○ allows rapid convergence without complex coordination
  ○ applications receive notifications about topology changes
Distribution & replication methods optimized for the type of state
- Based on size and read/write access patterns

Application Intents
- immutable
- durable & replicated

Global Network View
- eventually consistent
- fully replicated

Flow Table Entries
- strongly consistent
- partitioned

3-way replication
- H/A execution via distributed queues

Optimistic Replication
- gossip based
- anti-entropy
- partial ordering

Master/Backup Replication
Modularity Objectives

- Increase architectural coherence, testability and maintainability
  - establish tiers with crisply defined boundaries and responsibilities
  - setup code-base to follow and enforce the tiers

- Facilitate extensibility and customization by partners and users
  - unit of replacement is a module

- Avoid speciation of the ONOS code-base
  - APIs setup to encourage extensibility and community code contributions

- Preempt code entanglement, i.e. cyclic dependencies
  - reasonably small modules serve as firewalls against cycles

- Facilitate pluggable southbound
ONOS Modules

- Well-defined relationships
- Basis for customization
- Avoid cyclic dependencies
What’s coming on December 5th?

- **ONOS with all its key features**
  - scalability, high-availability, performance
  - northbound abstractions (application intents)
  - southbound abstractions (OpenFlow adapters)
  - modular code-base

- **Open source**
  - ONOS code-base on GitHub
  - documentation & infrastructure processes to engage the community

- **Use-case demonstrations**
  - SDN-IP, Packet-Optical

- **Sample applications**
  - reactive forwarding, mobility, proxy arp

*Check out posters -- learn details from ONOS architects and developers*