ONOS Intent Monitor and Reroute service: enabling plug&play routing logic

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Intent-Based Networking

- High level network policies (*intentions*):
  - give connectivity between node A and node B
  - consider only HTTP traffic
  - reserve 100 Mbps bandwidth on the path
- Network complexity abstraction
- Intent submitted through North-Bound Interface (NBI) offered by SDN controller
  - *OpenDayLight*: Network Intent Composition interface
  - *ONOS*: Intent Framework
- Intent compilation hidden inside SDN controller
  - from high level *intentions* to low level *flow rules*
Open Network Operating System (ONOS)

- SDN Network Operating System built for Service Provider networks
- Intent Framework (in charge of intent compilation):
  - extensible (new intent and new compiler can be added)
  - recompilation in case of network failures
  - each intent is individually compiled
  - only shortest path logic for intent is available
Our objective

1. **Re-optimize the path** according to topology state and flow level statistics

2. **Different routing logic** other than shortest path

3. **Joint compilation** of multiple intents to consider a global network objective (e.g., minimizing Maximum Link Utilization - MLU - )

4. **No impact** on ONOS high performance (external routing logic)
Intent Monitor and Reroute Service

- IMR exposes statistics as a traffic matrix based on the intent to an Off-Platform Application (OPA)
  - Internally it keeps track of the Intent <-> FlowRule mapping
- OPAs can re-route an intent through IMR API specifying for each intent a specific path
- IMR gets intent statistics and intent re-compilation event from the Intent Manager
ONOS Integration

IMR enables:
- Decoupling of routing logic from application
- Plugging of external Traffic Engineering Schemes (e.g. ML/AI algorithms)
- Joint external re-compilation of multiple intents
IMR APIs (CLI/REST)

- ONOS applications or users can require the monitoring and re-routing of intents

- CLI APIs
  - `imr:startmon appID appName [intentKey]`
  - `imt:stopmon appID appName [intentKey]`

- REST APIs: external applications (OPAs) can retrieve statistics and require re-routing
  - `GET /intentStats[/appID/appName/intentKey]`
  - `POST /reRouteIntents`
  - `GET /monitoredIntents[/appID/appName/intentKey]`
ONOS application which enables SDN network to connect to legacy IP networks using Border Gateway Protocol (BGP) while appearing externally as a traditional Autonomous System (AS)

- both BGP peering and AS-to-AS traffic managed through intents
- Extended SDN-IP: all the transit traffic intents are monitored via IMR
Off-Platform Application Routing Logic

- OPA logic is independent from the application
  - collect TMs from ONOS via IMR’s REST API
  - apply the CRR (or the selected routing logic)
  - schedules the activation of the routing
  - applies the routing via IMR’s REST API

- Clustered Robust Routing (CRR) [1]
  - computes a set of robust routing configurations with a guaranteed minimum holding time
  - tunable trade off between completely dynamic and completely stable routing

Tests

- SDN-IP modified version (IMR integration)
- OPA + CRR application
- Emulation of Abilene backbone topology (using Mininet)
- Replay a subset of 3-days Traffic Matrices using iperf (we played 5 minutes of Abilene TM every 15 seconds)
Results

![Graph showing MLU % over days, comparing Legacy SDN-IP and Extended SDN-IP + CRR OPA](image-url)
Results - Dynamic

Normalized average MLU

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<th>Relative noise $\alpha$ [%]</th>
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Conclusions

IMR can improve network performances:
- decoupling routing logic from application
- integrating external routing logic
- providing per-intent statistics
- jointly (re)compiling multiple intents

Future Works
- gRPC support
- Multi path routing (ECMP)
- Monitoring of additional type of ONOS intents (now only Point To Point and Link Collection Intents are supported)
Open Source Contribution

- IMR integrated in ONOS 1.13.0 Nightingale

- Documentation
  https://wiki.onosproject.org/x/hoQgAQ

- Demo
  Intent FWD app + external greedy routing alg
  https://youtu.be/hS04pch1eAq
Thanks!
Questions?

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