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Compare “learningSwitch” and “intentForward”, state in your opinion, how are they different from each other? Do they behavior differently with varied topology?

"learningSwitch" is a basic SDN application that functions as a Layer 2 (L2) switch. It operates by learning the source and destination MAC addresses of incoming packets and creating flow rules to forward packets based on this information. This application is stateful, maintaining a forwarding table to minimize packet flooding and enhance network efficiency.

"intentForward" is a more advanced SDN application that implements intent-based networking. It defines high-level network intents specifying how traffic should be forwarded in the network. Intent-based networking offers a more abstract, policy-driven approach to network management. Unlike "learningSwitch," it is stateless, relying on the ONOS core to manage flows required to fulfil the intents.

Their differences are listed below.

1. **Abstract level**
   “intentForward” is at a higher level than “learningSwitch”, thus more abstract. While “learningSwitch” controls individual switch via controller, “intentForward” takes a more abstract approach by controlling data flow using intent. For example, “Pass from host 1 to host 2” is an intent that the core ONOS controller uses to generate instructions to individual switches. However, in “learningSwitch”, we program the logic of individual switches, such as the use of a forwarding table and flooding mechanism.
2. **Services involved**
   “learningSwitch” uses lower-level services, such as FlowRuleService that dictates the actions that should be done to the specified packets that reaches the switch, while “intentForward” uses higher-level services, such as IntentService that submits the intent to ONOS core controller, so that the core controller can update the instructions accordingly
3. **Varied topology**
   “intentForward” offers a more flexible and it can adapt to any topology if the intent is provided, and even when the topology changes suddenly (e.g. dropped link). However, “learningSwitch” can be more restrictive, for example, our implementation in a ring topology configuration may cause the whole network to be flooded with broadcast messages, as the broadcast messages (by FLOOD) may loop around the ring infinitely. In addition, we need to manually handle the sudden change in topology as well, for example using TTL in forwarding table, otherwise packets may not be able to reach the destination.

Difficulties faced during learning/programming on ONOS and how do you solved them?

I did not faced much trouble programming on ONOS, because ONOS API is very well designed. The idea of using interfaces, the use of clean architecture and Object-Oriented Programming, made the API easy to understand and code. The segregation of APIs into different services allows me to easily figure out which service to use at a particular situation. In addition, the APIs are very well documented and there were sufficient examples given in the official samples git repository. The Piazza discussions and tutorials are also very helpful in the process.

The only difficulty I faced is probably the inability to start ONOS properly. It is probably due to the lack of RAM (8GB), causing some services of ONOS to not start when I run “bash createServer.sh”, e.g. “AdminService not found”, “command app not found”. It was very hard to debug and it took very long as I was unsure whether it is caused by my code, maven build, ONOS or Mininet. It was also impossible to search online, as no one else has faced the same problem. Overtime, I found out the behaviour is random and ONOS should be able to start regardless of my code, thus I concluded that it’s not caused by my own code. Consequently, I borrow my brother’s PC to try run the ONOS image, and the problem is gone, and I could proceed to debug my own code, which requires a few small changes.

Overall, the programming experience was very smooth and it took about two hours, however the unknown behaviour of ONOS in my laptop took a few days for me to figure out the issue.