OpenState is a stateful pipeline design (originally developed as an OpenFlow extension), that allows packets to be forwarded on the basis of “flow-states”, maintained and updated by the fast path itself as a consequence of packet-level events (i.e. table match) and timers. The demo presents an application for failure resiliency that exploits the fast adaptation of the forwarding behavior in the data path. This application provides i) a programmable detection mechanism based on switches’ periodic link probing and ii) a fast reroute of traffic flows even in case of distant failures, regardless of controller availability. It can guarantee short (i.e. few ms) failure detection and recovery delays, with a configurable trade off between overhead and failover responsiveness.

An OpenState equivalent design can be obtained in P4 by combining:
- Registers (stateful memories);
- Hash value generators (functions that operate on a stream of bytes from a packet to produce an integer);
- Definition of new header types, tables and actions.

**Control flow at a glance:**
- Hash generators produce a index to access registers
- State lookup → copy from registers to packet metadata
- State update → copy from action parameters to registers

**Pipeline**

1. **Path pre-planning:** primary and backup paths for each possible failure scenario are pre-computed and provisioned to switches at boot time.
2. **Tag based forwarding:** packet labels are used to distinguish between different forwarding behaviors, in order to perform:
   - Normal forwarding (tag=0)
   - Heartbeat-based link-level failure detection (tag=1)
   - Switch-to-switch failure signaling (tag=2)
   - Probing to check path availability after a failure (tag=3)
3. **Guaranteed failover delay:** depends on a target timestamp resolution.
4. **Minimize packet reordering:** timeout-based flowlet-aware mechanism to postpone the path failover up to the expiration of a burst of packets.

**Fast reroute FSM**

1. **Normal conditions**
   - primary path
2. **Heartbeat-based failure detection**
   - heartbeat probe
3. **Packets bounced back in case of failure**
   - heartbeat probe
4. **Periodic probing to check failed path**
   - periodic heartbeat

**References**