Hybrid Packet and Flow Processing with Flowlets

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Motivation: Two Ways of Processing Traffic

- Process as an **individual packet**
  - Advantages: Flexible, More control, Micro-decisions
  - Disadvantages: Slow
- Process as an **aggregate flow**
  - Advantages: Faster, Macro-decisions
  - Disadvantages: Not enough control and flexibility

- **Flowlets:** Process packets on per-packet *and* per-flow granularity
  - Best of both worlds!

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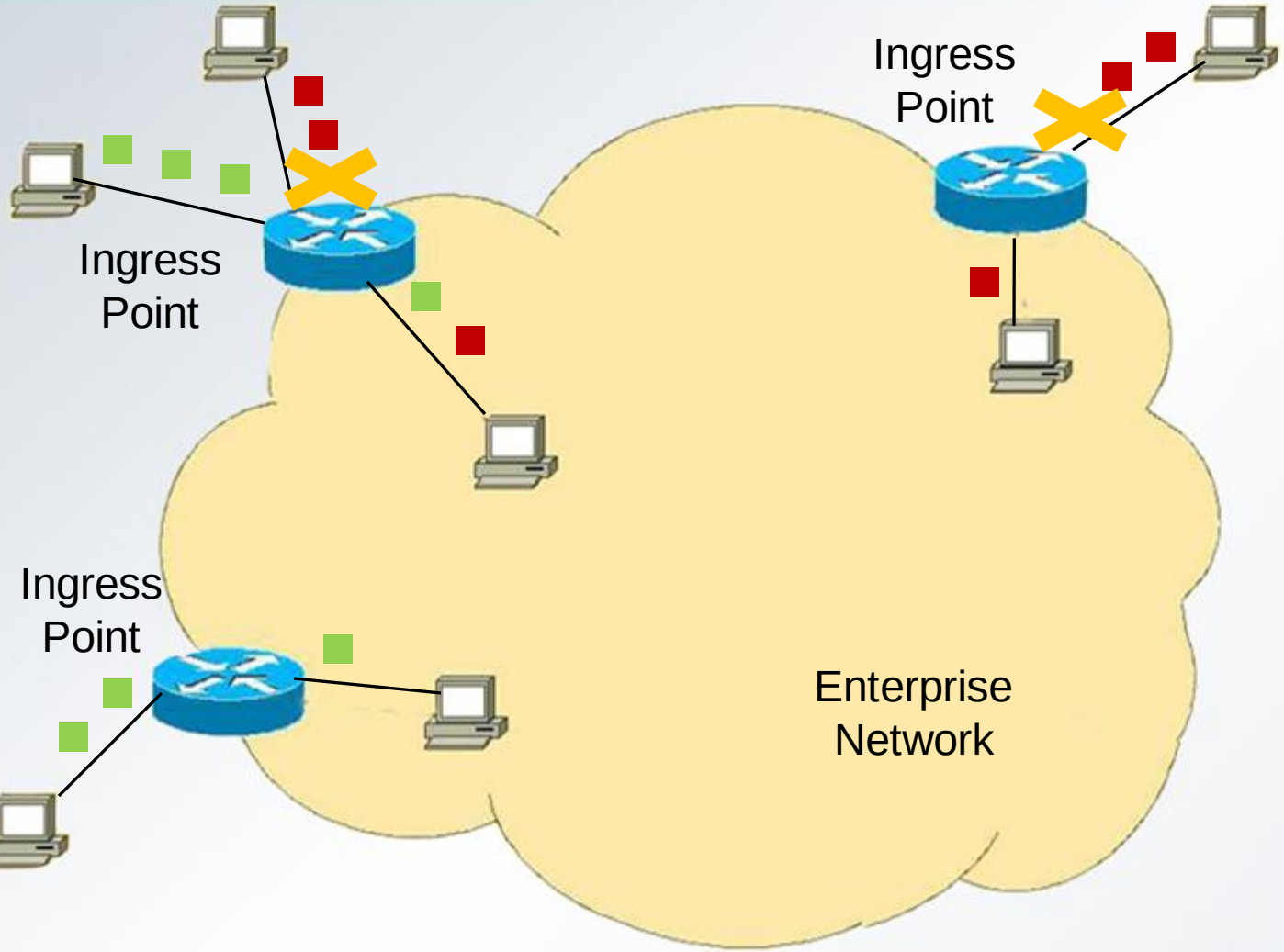
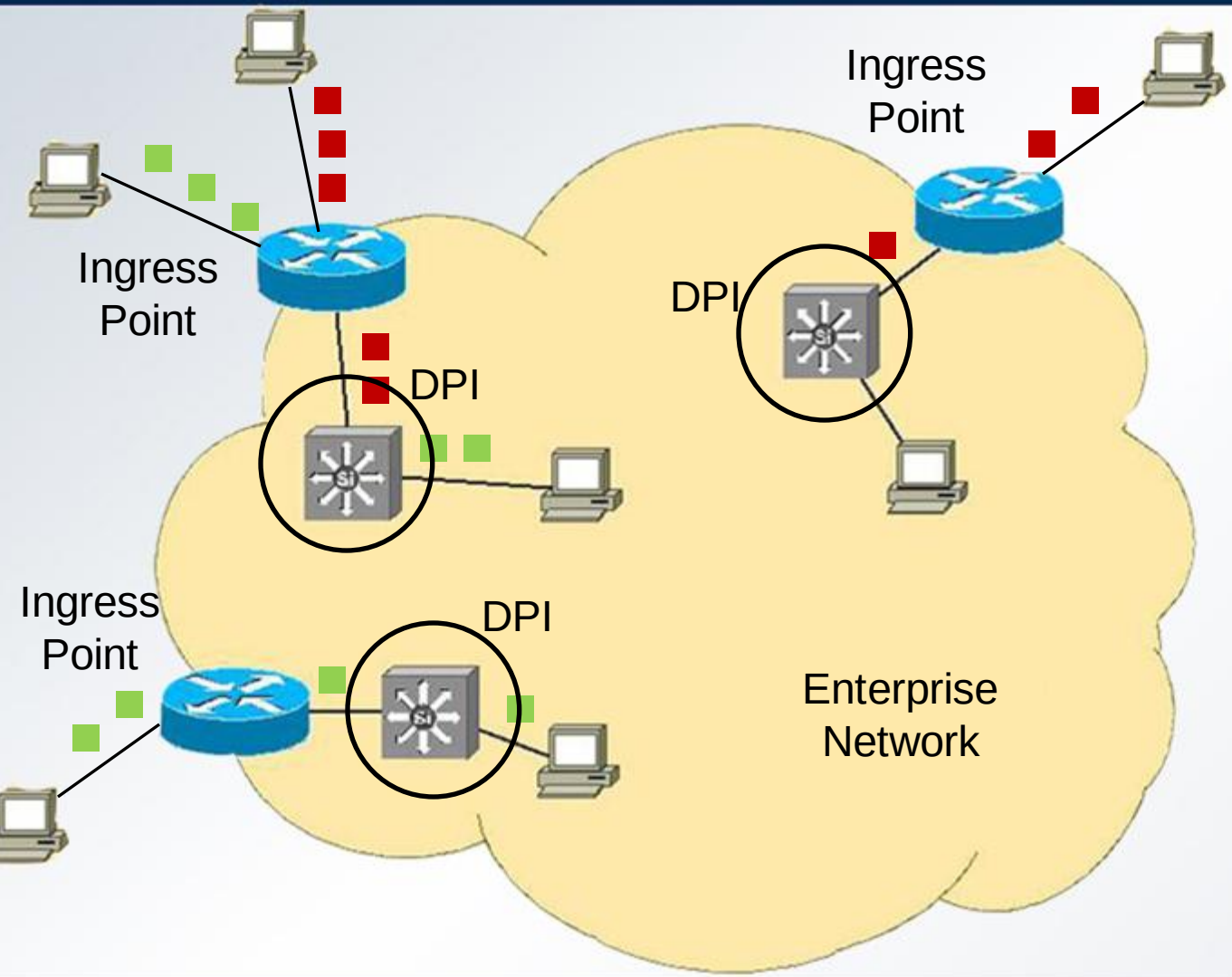
Example: Network Security (Flow-Based Only)



1. **Routers forward traffic using only packet header fields**
2. **Identify malicious traffic by examining packet data at line speed**

- **Normal traffic**
- **Malicious traffic**
- **Suspicious traffic**

Example: Network Security (Packet-Based Only, Distributed)



1. Deploy DPI boxes at each Ingress point

Disadvantages

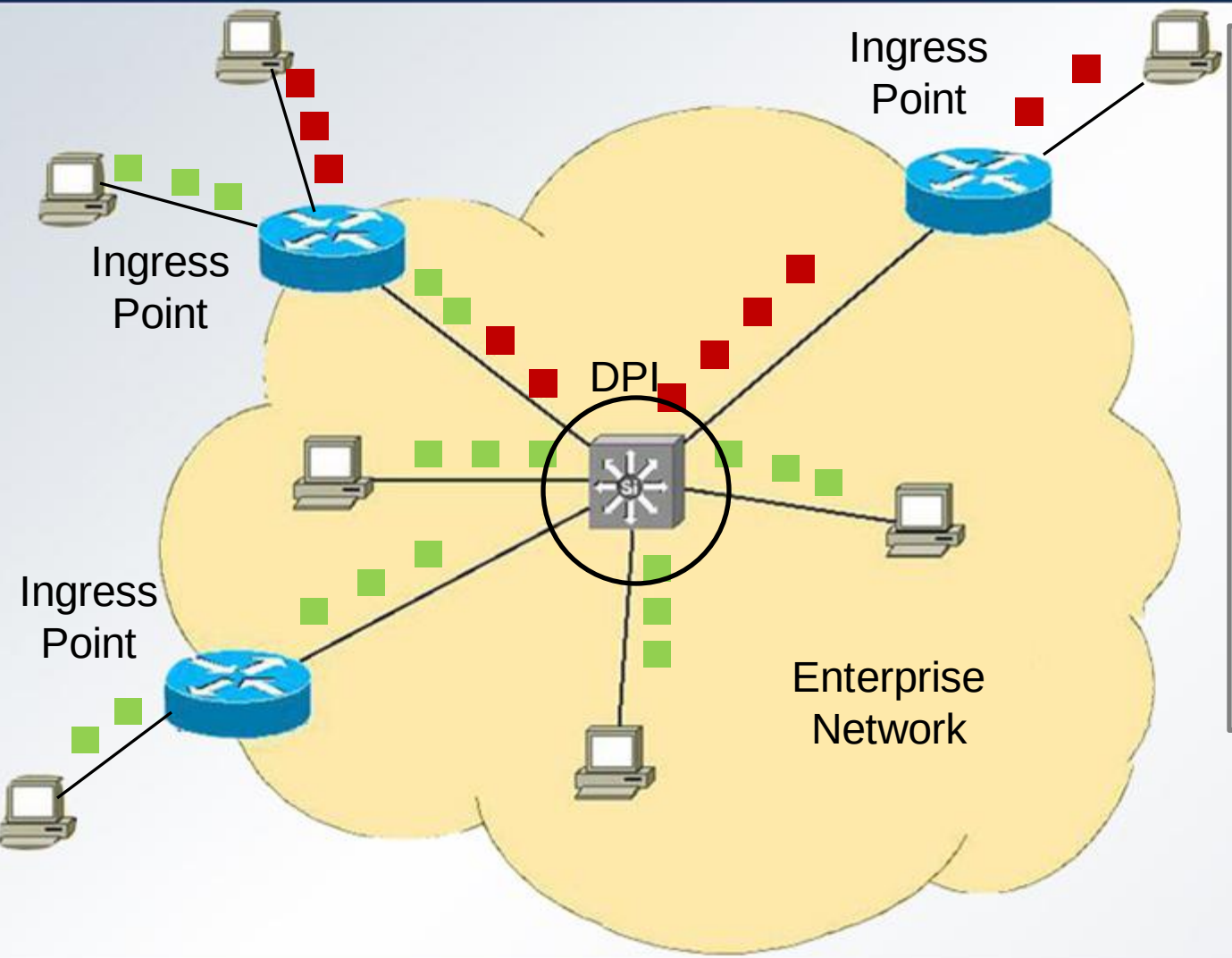
1. Distributed coordinated attacks
2. Space, Maintenance, Cost, Power

Normal traffic

Malicious traffic

Suspicious traffic

Example: Network Security (Packet-Based Only, Centralized)



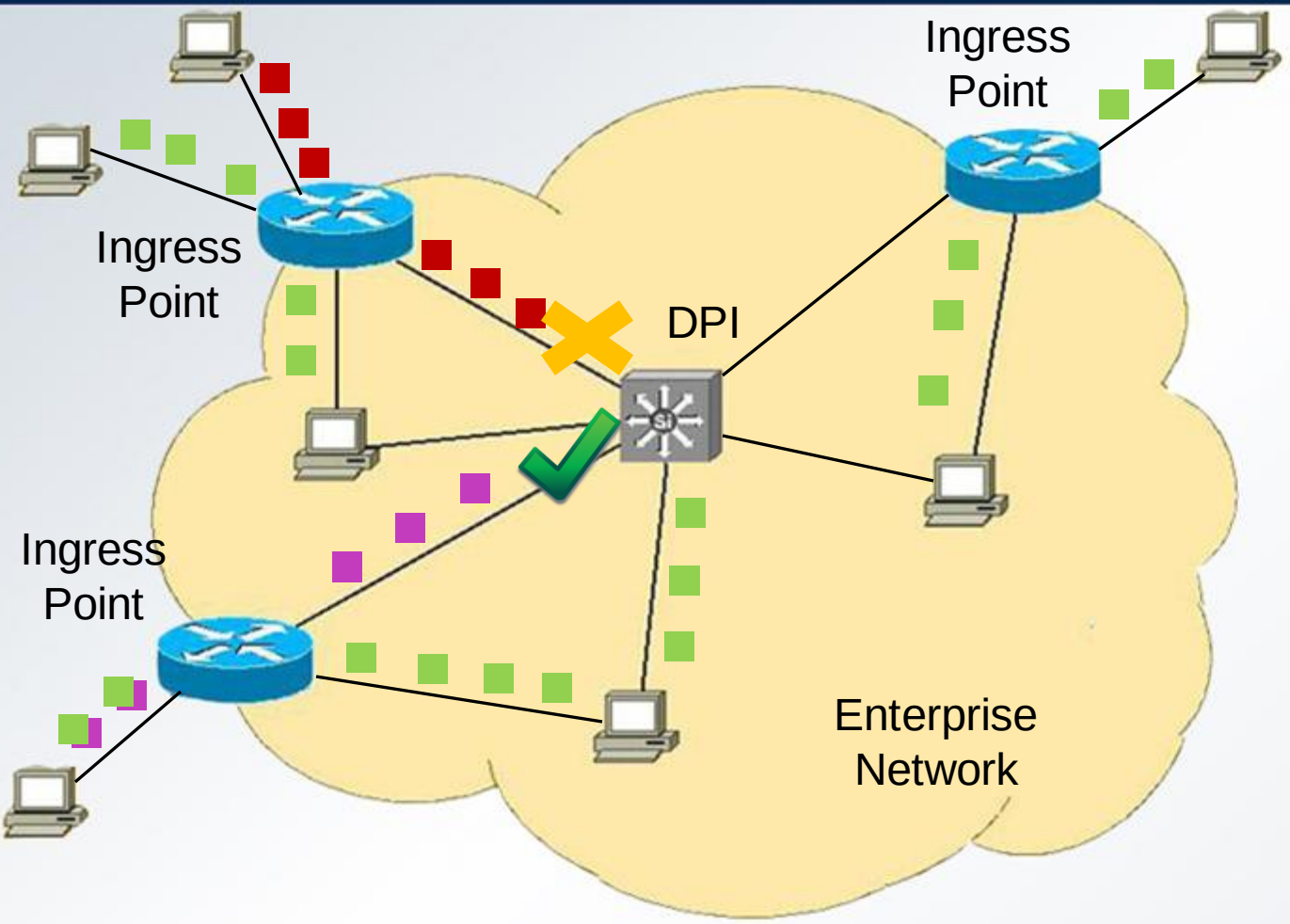
1. Redirect traffic through a centralized DPI

Advantages
1. Distributed attacks are detected
2. Less cost, power, maintenance

Disadvantages
1. Not scalable
2. Single point of failure

Normal traffic
Malicious traffic
Suspicious traffic

Better Solution: Both Packets and Flows



1. Redirect only suspicious traffic to the centralized DPI box.

Desired Properties

- Distributed monitoring
- Centralized decision making
- Packet by packet and Flow based processing

Normal traffic

Malicious traffic

Suspicious traffic

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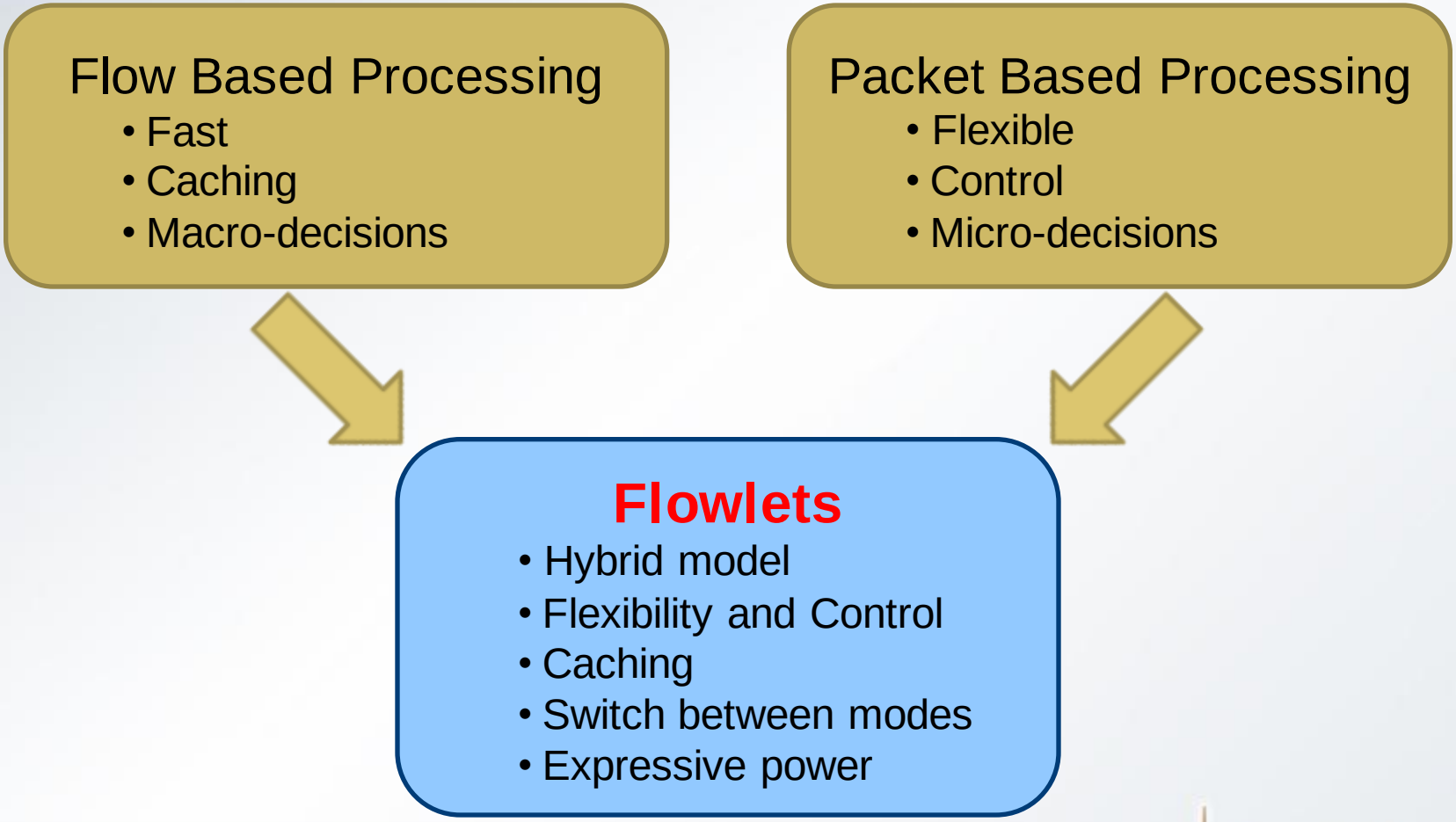
Neither Flow nor Packet-Based Processing is Sufficient

	Examples	Speed	Caching	"Macro" Decisions	"Micro" Decisions	Control/ Flexibility
Flow-based processing	MPLS, Forwarding tables, Openflow					
Packet-based processing	Active Networks, DPI, Click					

We need both !!

Main Idea: Combine Packet and Flow Processing



Talk Outline

- Motivation
- Example: Enterprise Security
- Flowlets: Hybrid Processing
- Background
  - OpenFlow
  - Click
- OpenFlow Click Element
- Demonstration
- Implementation Details and Decisions
- Future work and Summary

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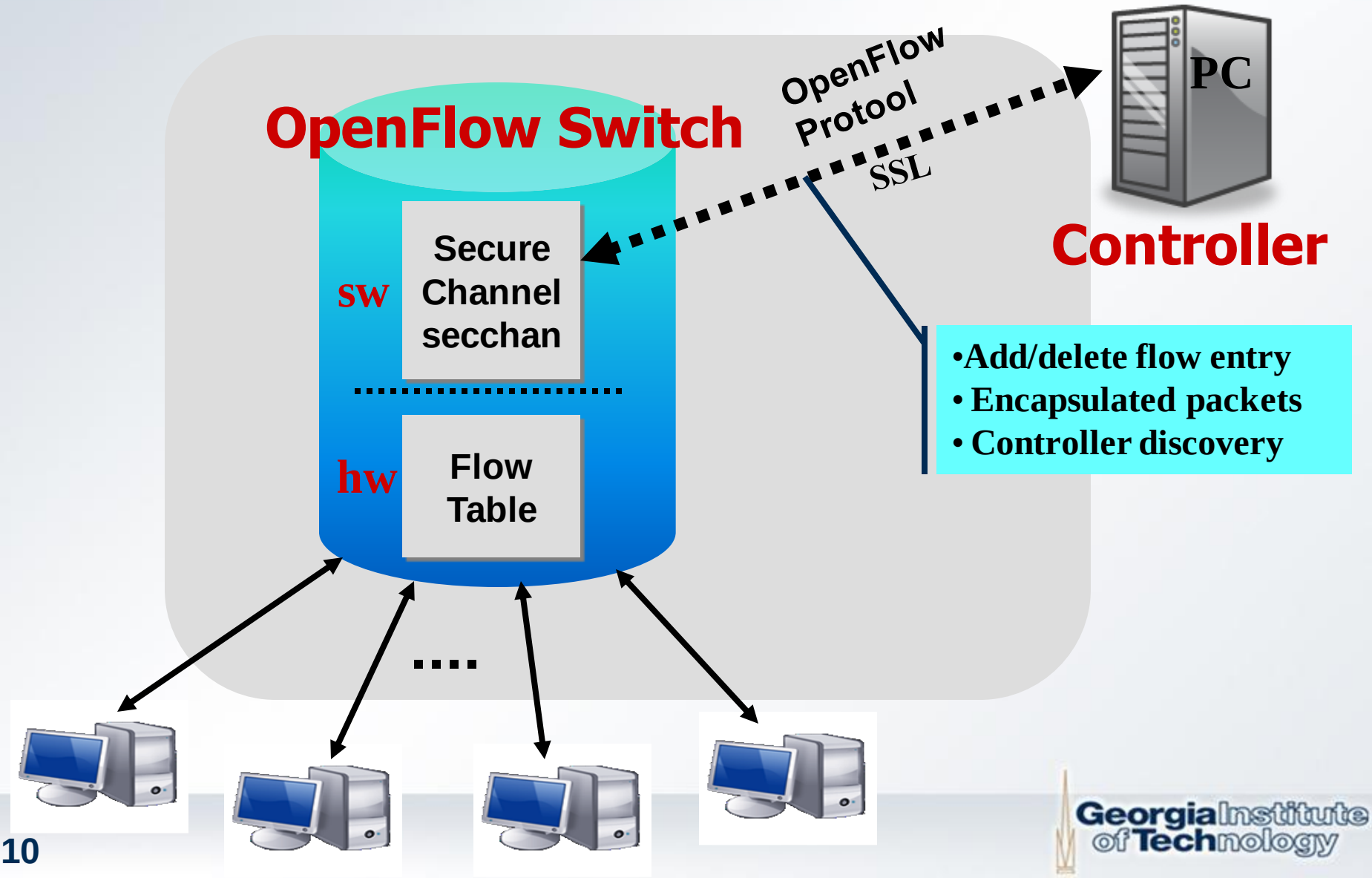
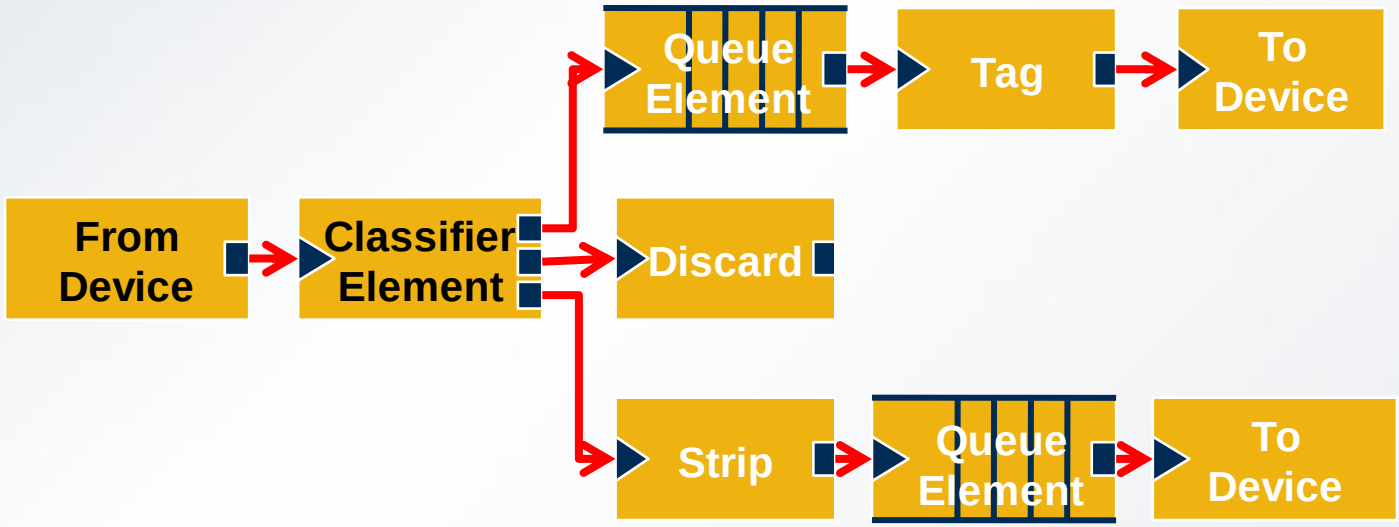
Flow-Based Processing: OpenFlow



Packet-Based Processing: Click

- Easy to program
- Intuitive configuration language
- Provides more control
- Large elements library



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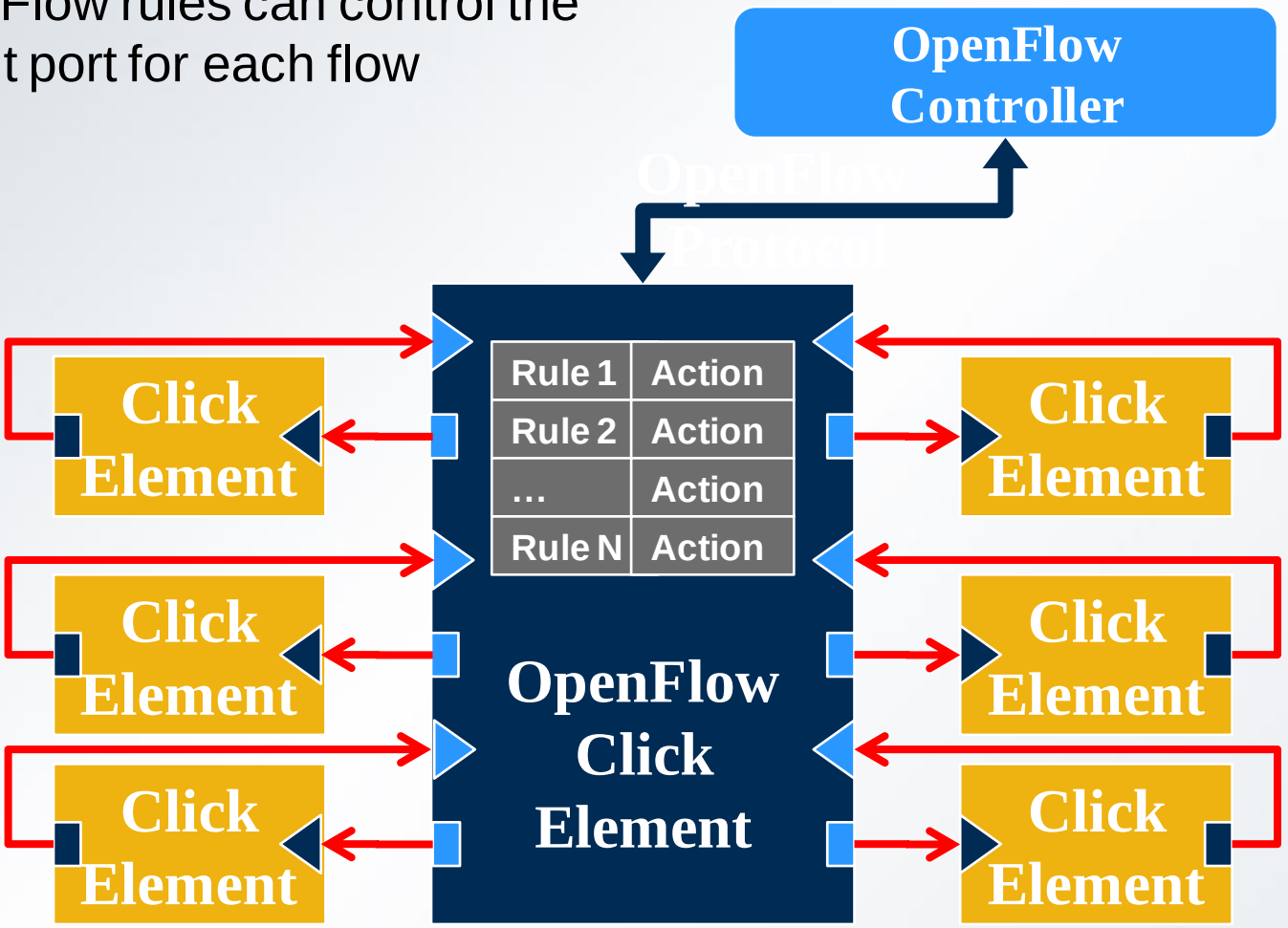
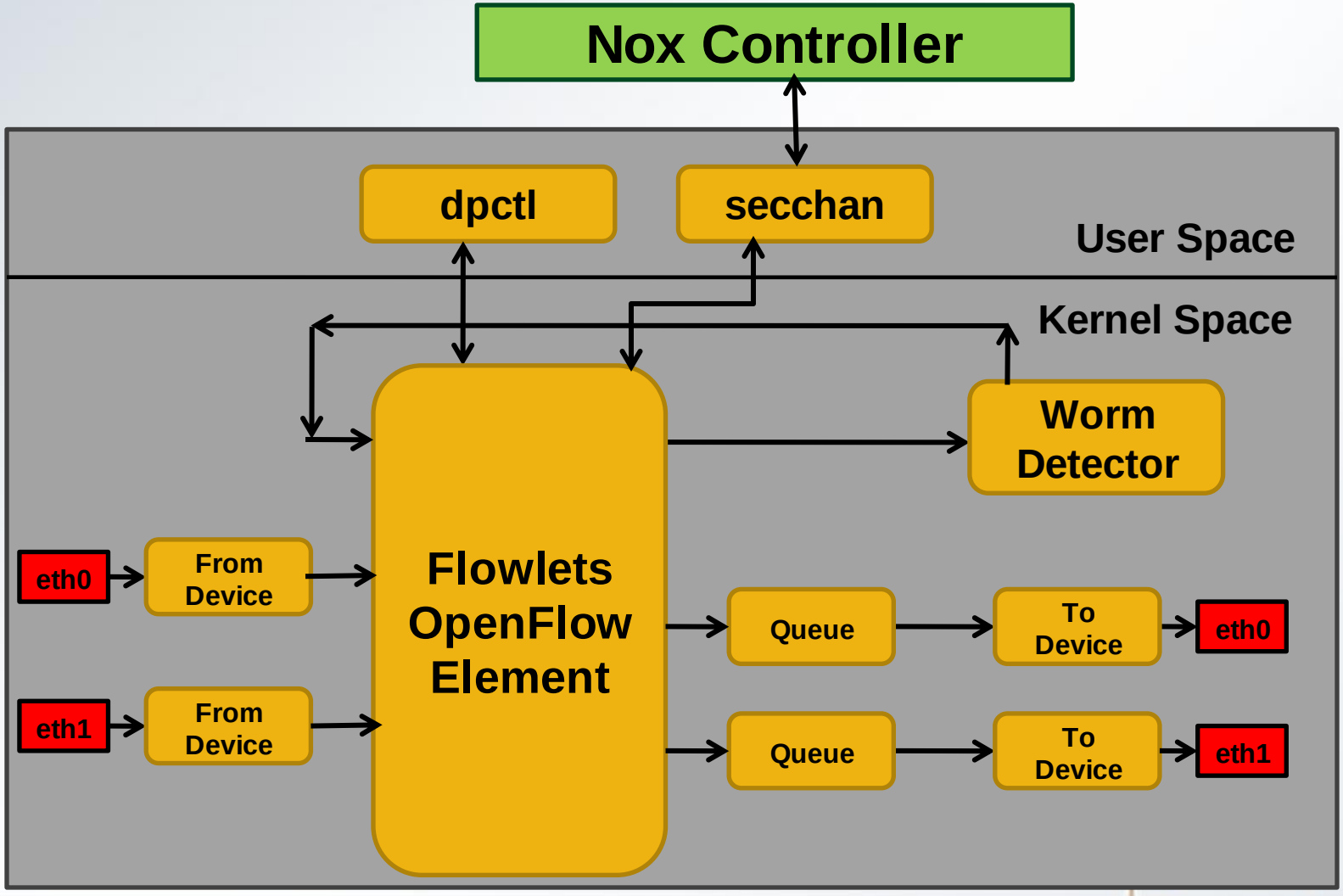
Hybrid: OpenFlow Click Element

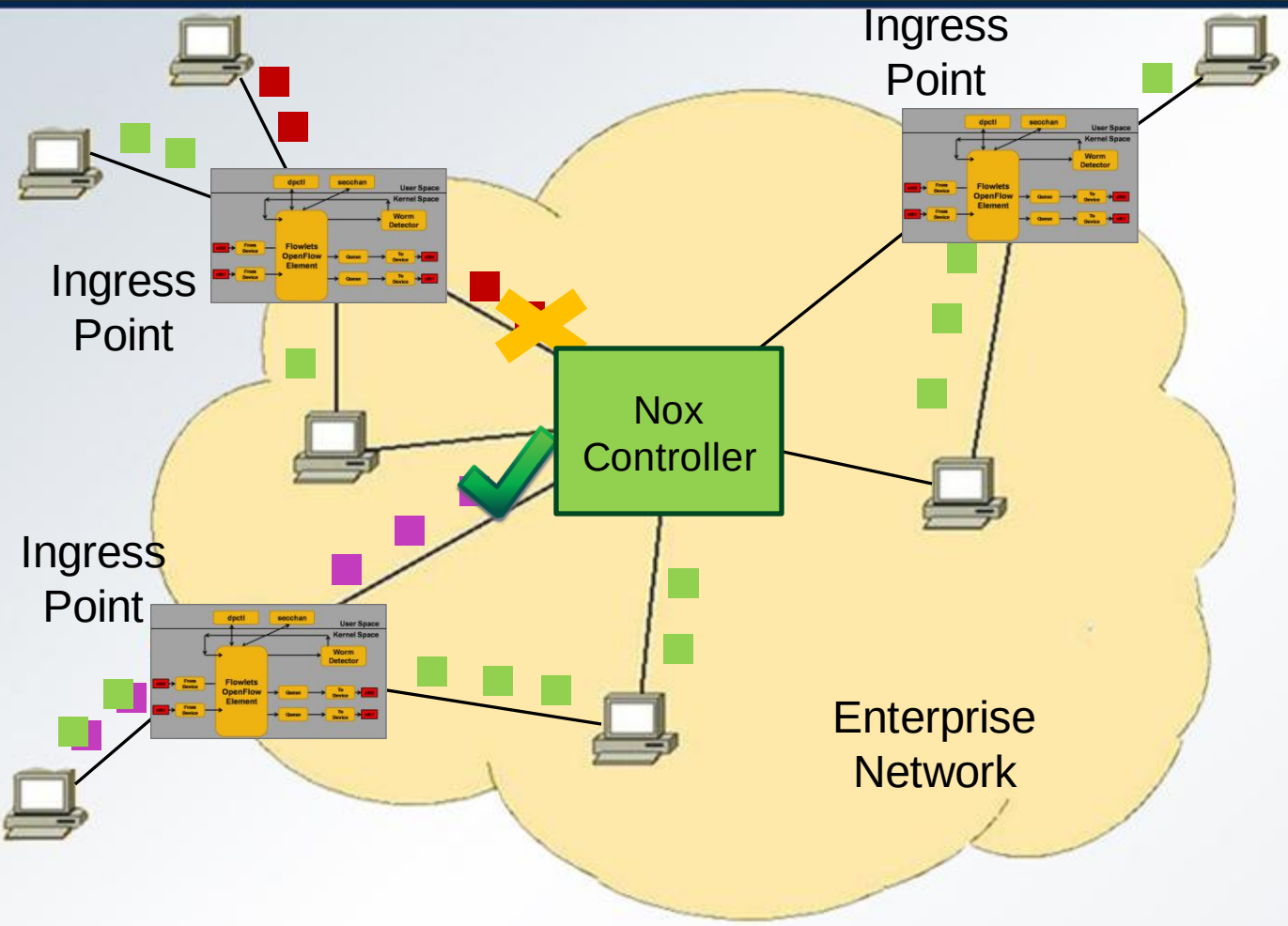
OpenFlow rules can control the output port for each flow



Example: Enterprise Security



Enterprise Security with Flowlet Processing



1. Redirect only suspicious traffic to the centralized DPI box.

Desired Properties

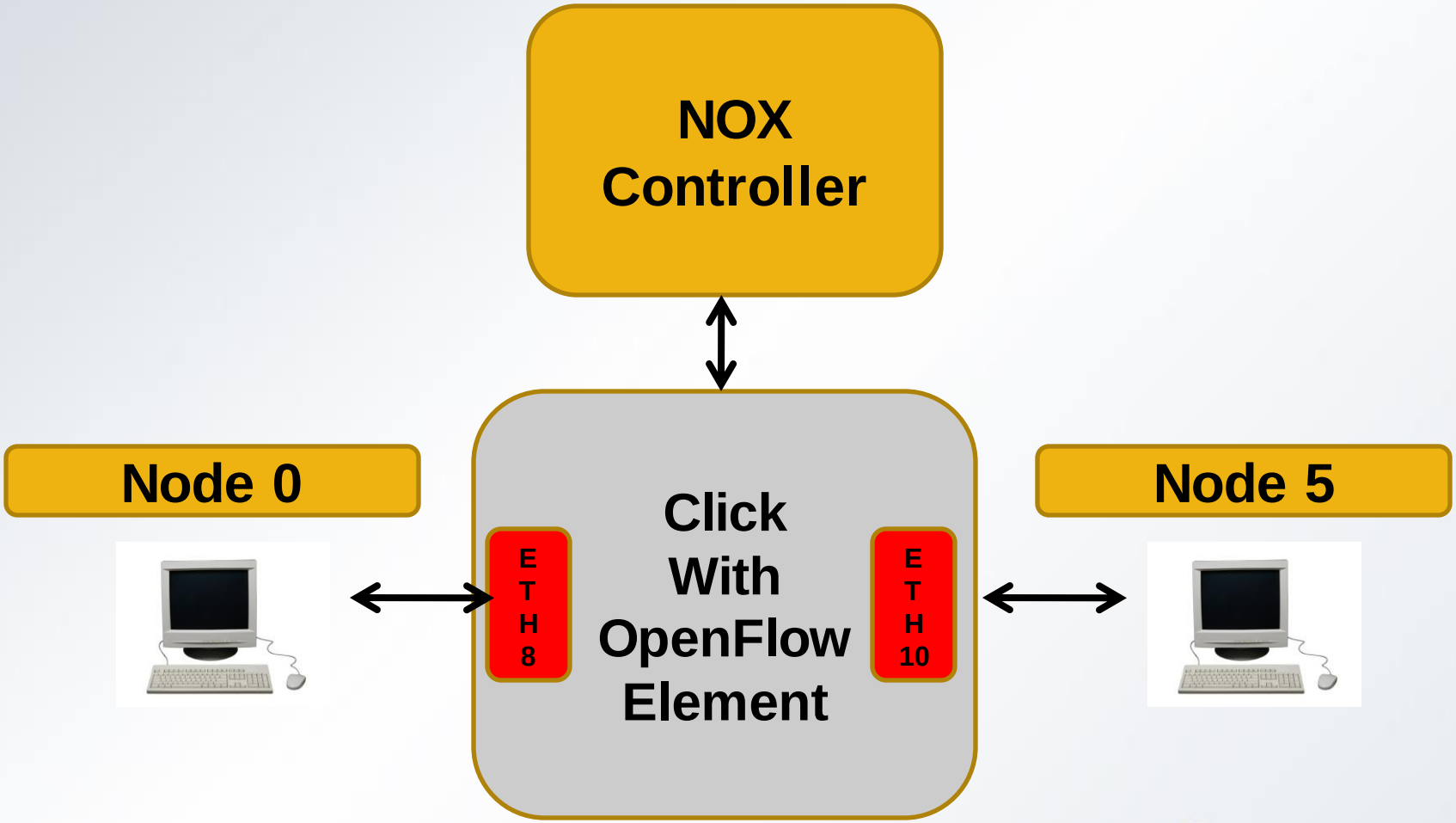
- Distributed monitoring
- Centralized decision making
- Packet by packet processing
- Flow based processing

Normal traffic

Malicious traffic

Suspicious traffic

Demonstration



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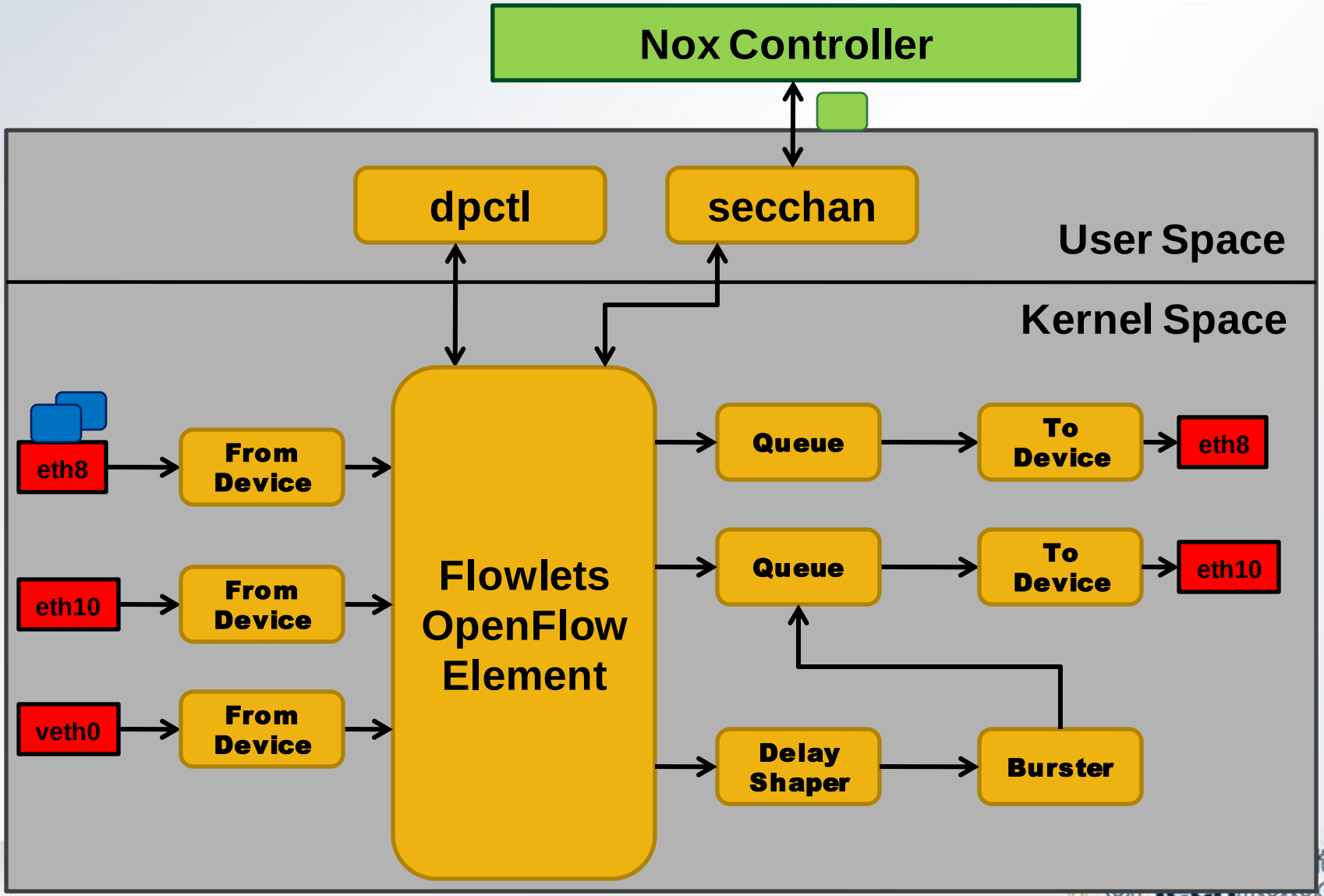
Demonstration



Demo Click Configuration

```
q1 :: Queue;
q2 :: Queue;
q3 :: Queue;
s :: Ofswitch;

FromDevice(eth8, PROMISC true) -> [0]s;
FromDevice(eth10, PROMISC true) -> [1]s;
FromDevice(veth0, PROMISC true) -> [2]s;

s[0] -> Print("Received from eth8", MAXLENGTH 100) -> q1;
s[1] -> Print("Received from eth10", MAXLENGTH 100) -> q2;
s[2] -> Print("Received from veth0", MAXLENGTH 100) -> q3 ->

DelayShaper(2) -> b::Burster(0.1) -> q2;

q1 -> ToDevice(eth8);
q2 -> ToDevice(eth10);
```

Implementation Decisions

1. Implement new Click element using existing OpenFlow switch source code.

2. Implement element as kernel module.

3. Minimize changes to existing OpenFlow code base.

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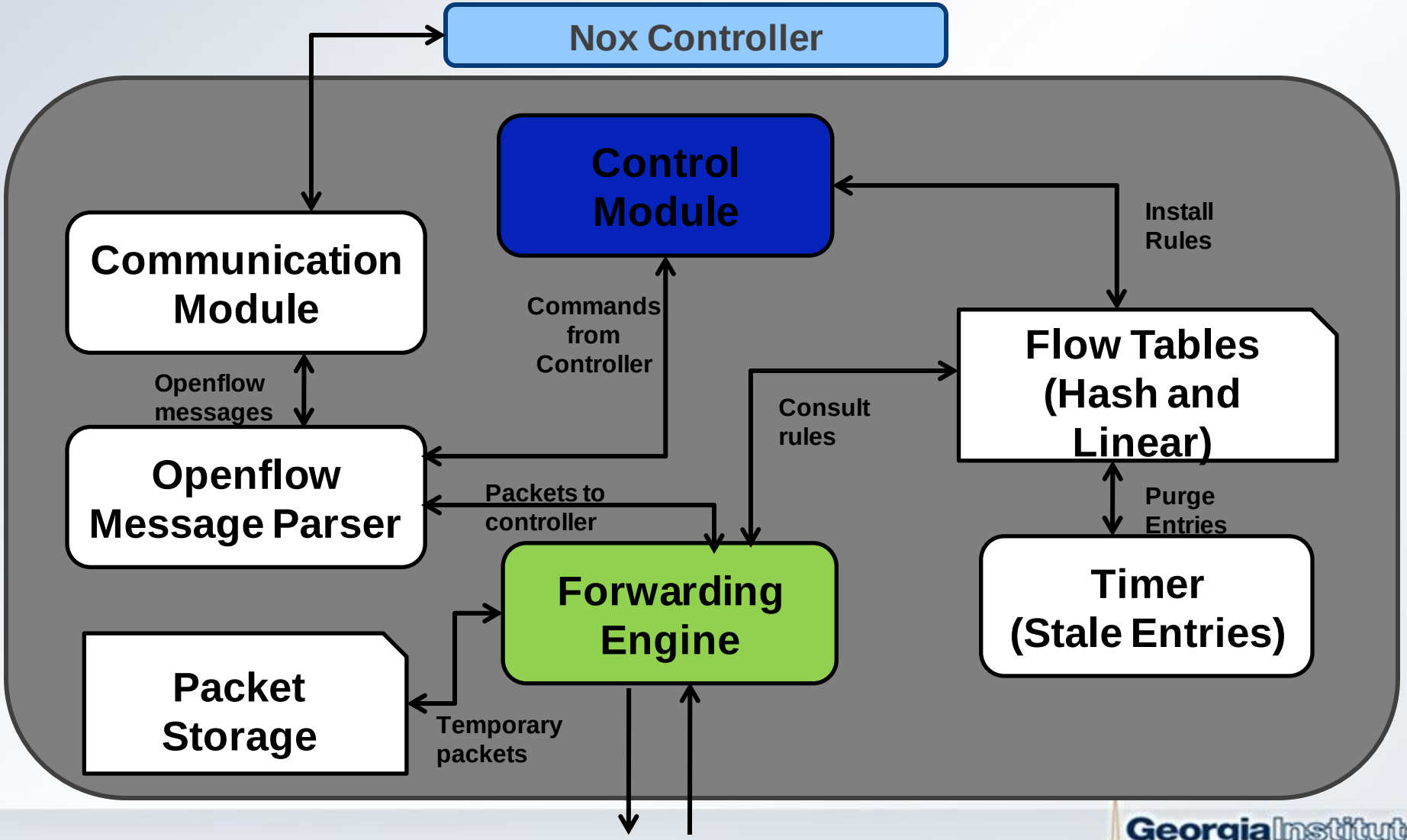
Element Architecture



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Other Applications of Flowlets

- Loop detection: TTL zero
- Inserting/Deleting extra bits from packet headers (Splicing)
- Packet sampling
- Duplicate packet detection

Future work

- User-space element
- Click vendor-specific action
- Dynamic port addition/deletion
- Dynamic element load/unload
- Dynamic sub-graph load/unload

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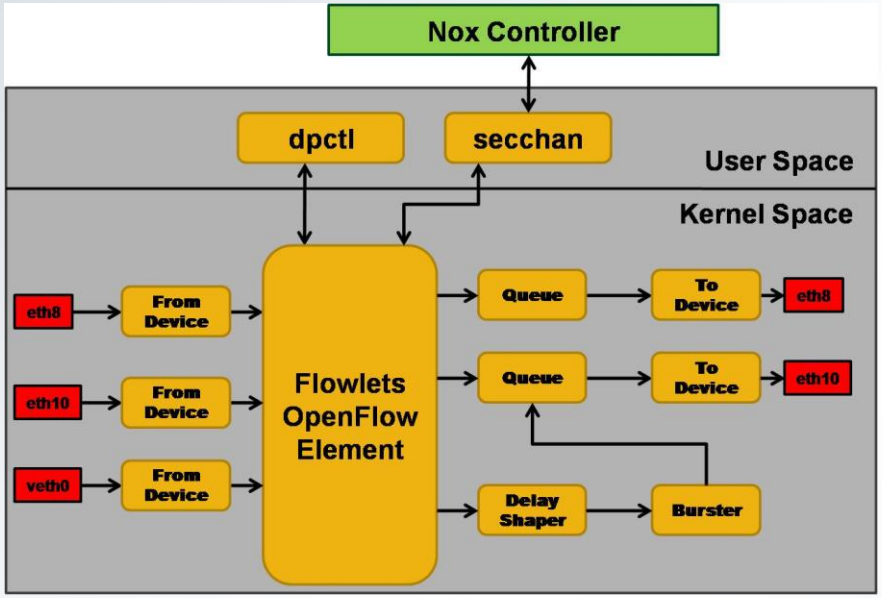
Summary

http://www.openflowswitch.org/wk/index.php/OpenFlowClick



Flowlets

- Hybrid model
- Flexibility with control
- Caching
- Switch between modes
- Expressive power

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Challenges

- Locking
- Refactoring code in correct modules
- Memory allocation
- Multi-threaded code
- Debugging
- Mixing C/C++ code

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