Consistent Updates for Software-Defined Networks: Change You Can Believe In!

Mark Reitblatt, Nate Foster,
Jen Rexford, and Dave Walker

The New York Times Technology | Personal Tech | Business Day

Bits

Amazon Cloud Failure Takes Down Web Sites

By CLAIRE CAIN MILLER | April 21, 2011, 4:40 PM

10:28 a.m. | Updated *to reflect status of the problem on Friday.*

A widespread failure in Amazon.com's Web services business was still affecting many Internet sites on Friday morning, highlighting the risks involved when companies rely on so-called cloud computing.

The problems, which began early Thursday morning, affected sites including Quora.com, Reddit.com, GroupMe.com and Sovogr.com, which all posted messages to their visitors about the issue. Most of the sites have been inaccessible for hours, and others were only partly operational.

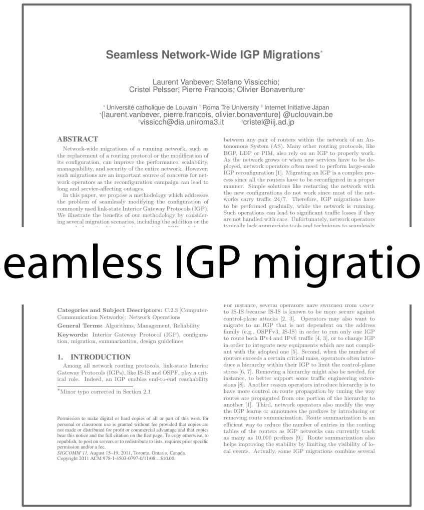
The Web companies use Amazon's cloud-based service to serve their Web sites, applications and files. Amazon's customers include start-ups like the social networking site Foursquare but also big companies like Pfizer and Nasdaq.

Amazon, which is a leader in this business, lets these companies rent space on its servers and take advantage of its big data centers and computing power. But that gives the companies little control if the servers fail.

"We don't think the cloud is enterprise-ready," said Jimmy Tam, general manager of Peer Software, which provides data backup for businesses. "Are you really going to trust your corporate jewels to these cloud providers?"

"[A] network change was performed as part of our **normal** AWS scaling activities...
This change **disconnected** both the primary and secondary network simultaneously, leaving the affected nodes completely isolated from one another."

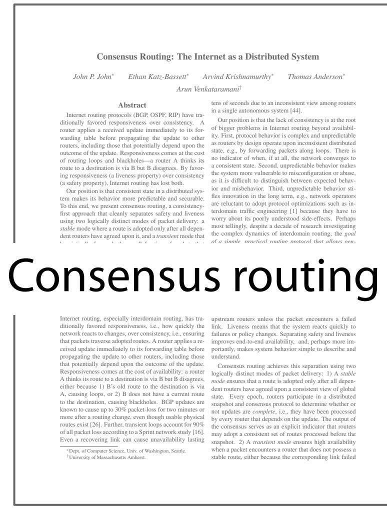
Prior Work



Seamless Network-Wide IGP Migrations

Laurent Vanbever; Stefano Vissicchio; Cristel Pelsser; Pierre Francois; Olivier Bonaventure

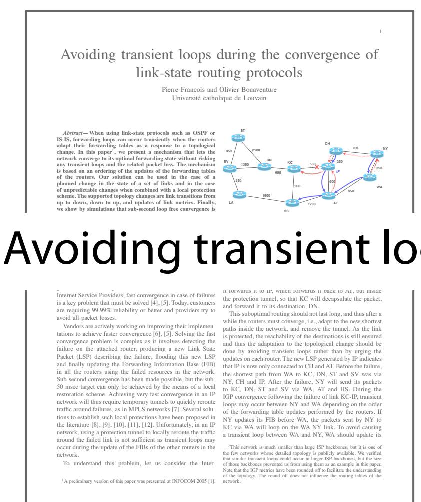
Seamless IGP migration



Consensus Routing: The Internet as a Distributed System

John P. John, Ethan Katz-Bassett, Arvind Krishnamurthy, Thomas Anderson, Arun Venkataramani

Consensus routing

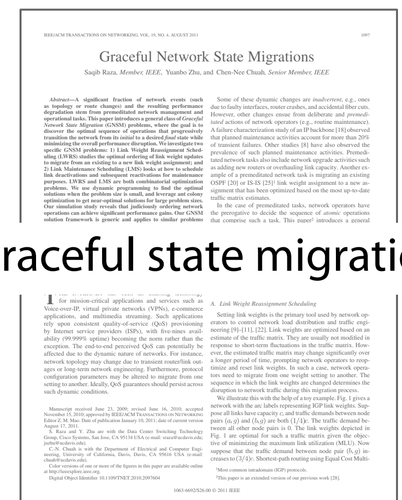


Avoiding transient loops during the convergence of link-state routing protocols

Pierre Francois and Olivier Bonaventure

Université catholique de Louvain

Avoiding transient loops

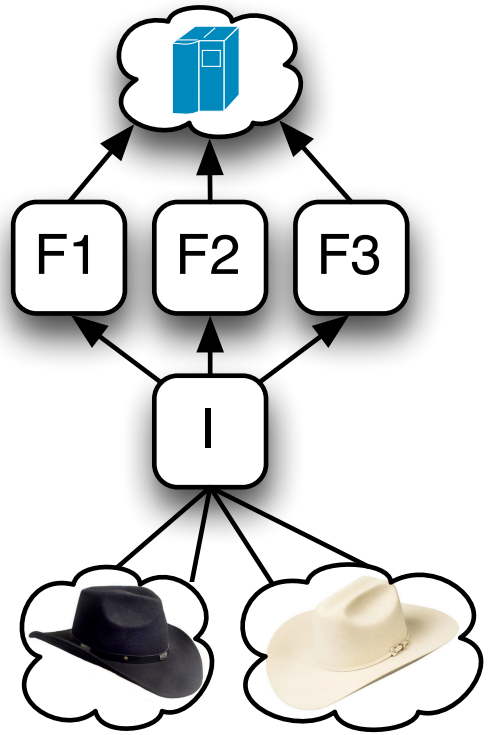


Graceful Network State Migrations

Saqib Raza, Member, IEEE, Yuanbo Zhu, and Chen-Nee Chuah, Senior Member, IEEE

Graceful state migration

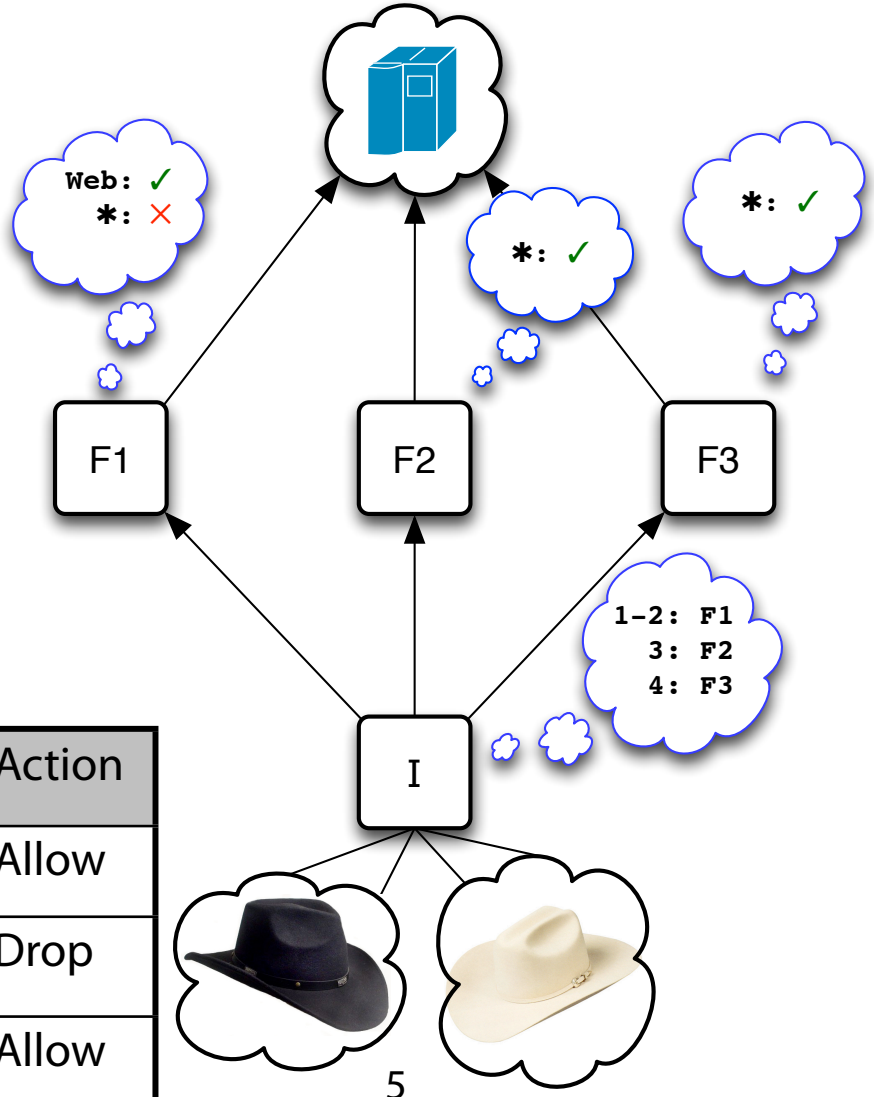
Example



Security Policy

Src	Traffic	Action
	Web	Allow
	Other	Drop
	Any	Allow

Initial Configuration



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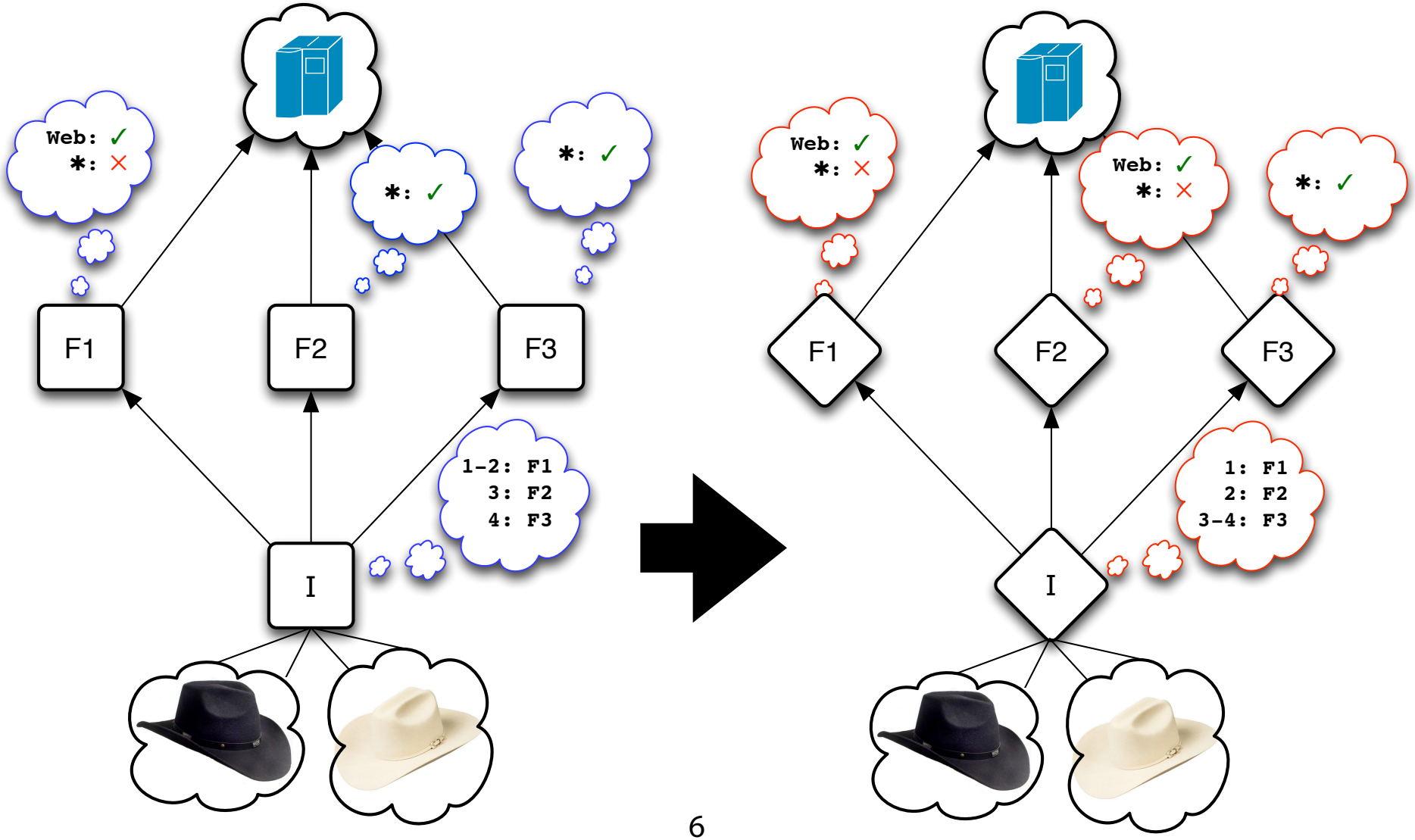
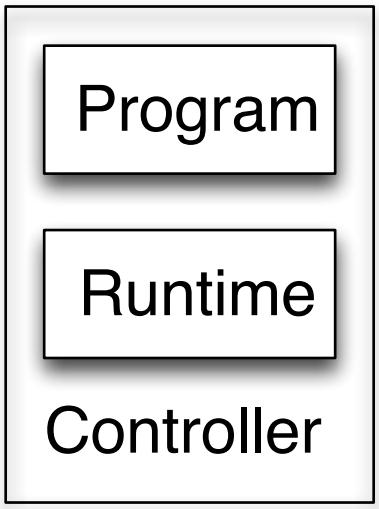
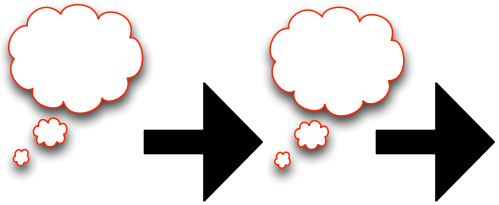
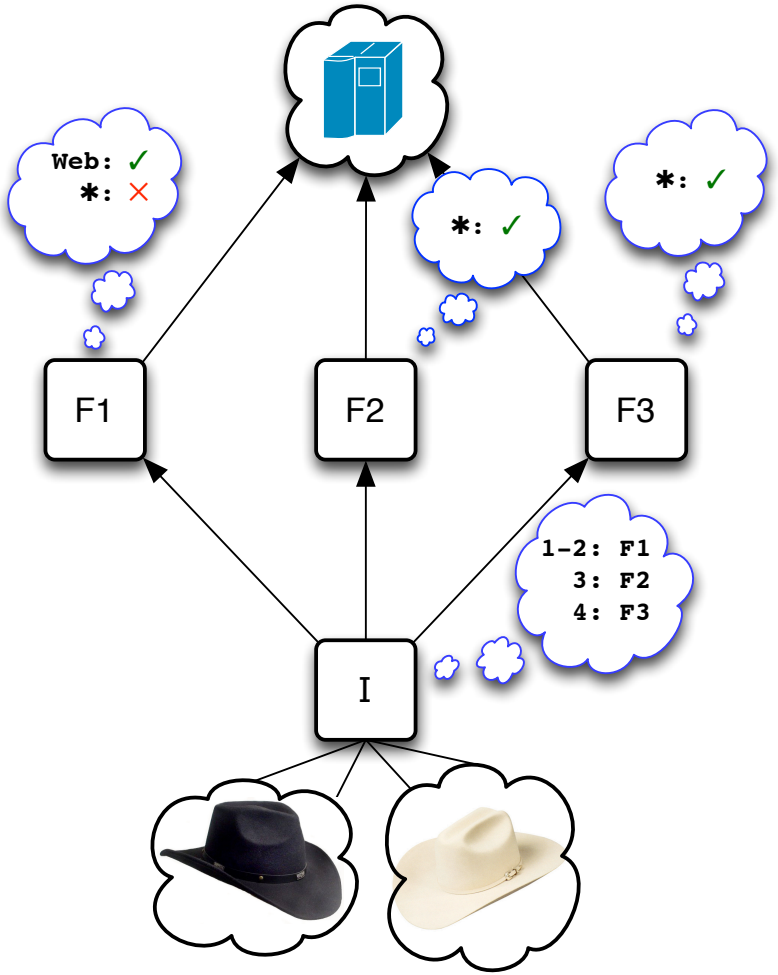
Redistribute Configuration



Software Defined Networks (SDN)



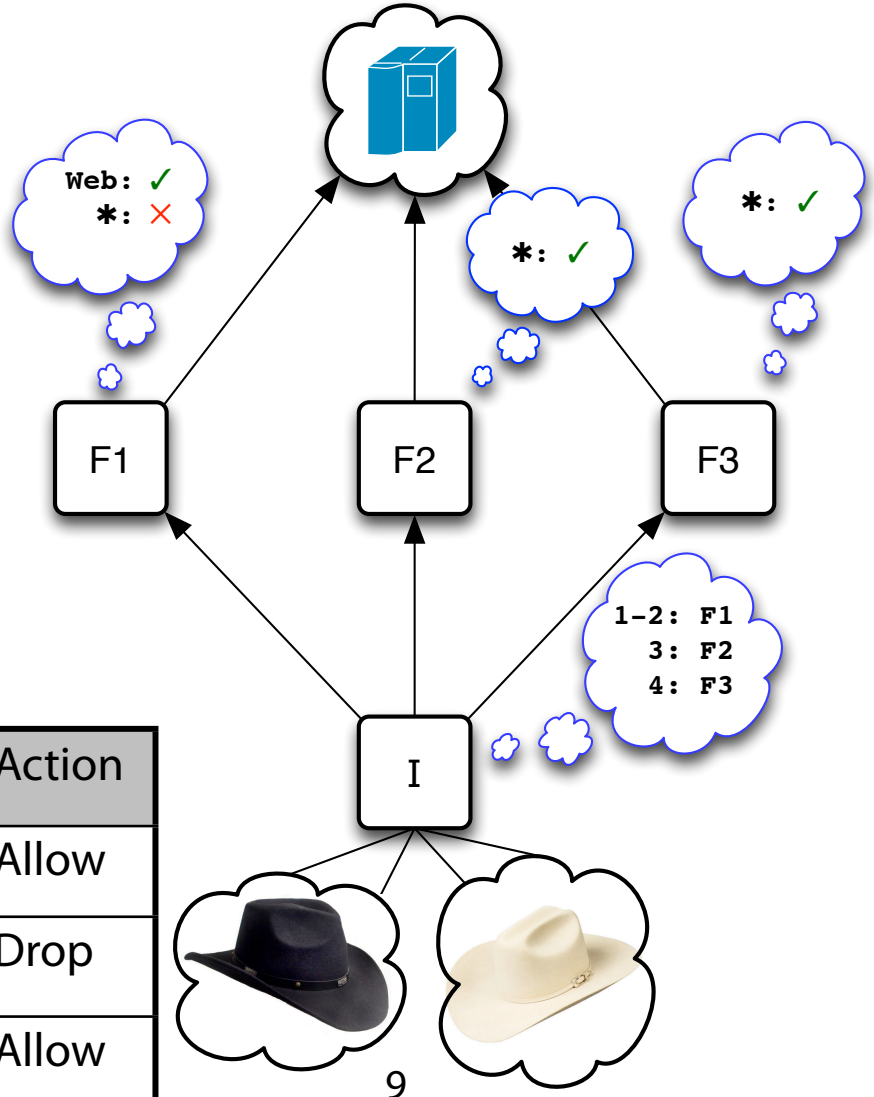




SDN Program

```
void main() {
... monitor ...
Conf = balance_load();
install(F1, Conf[F1]);
install( I, Conf[I]) ;
...
}
```

Initial Configuration



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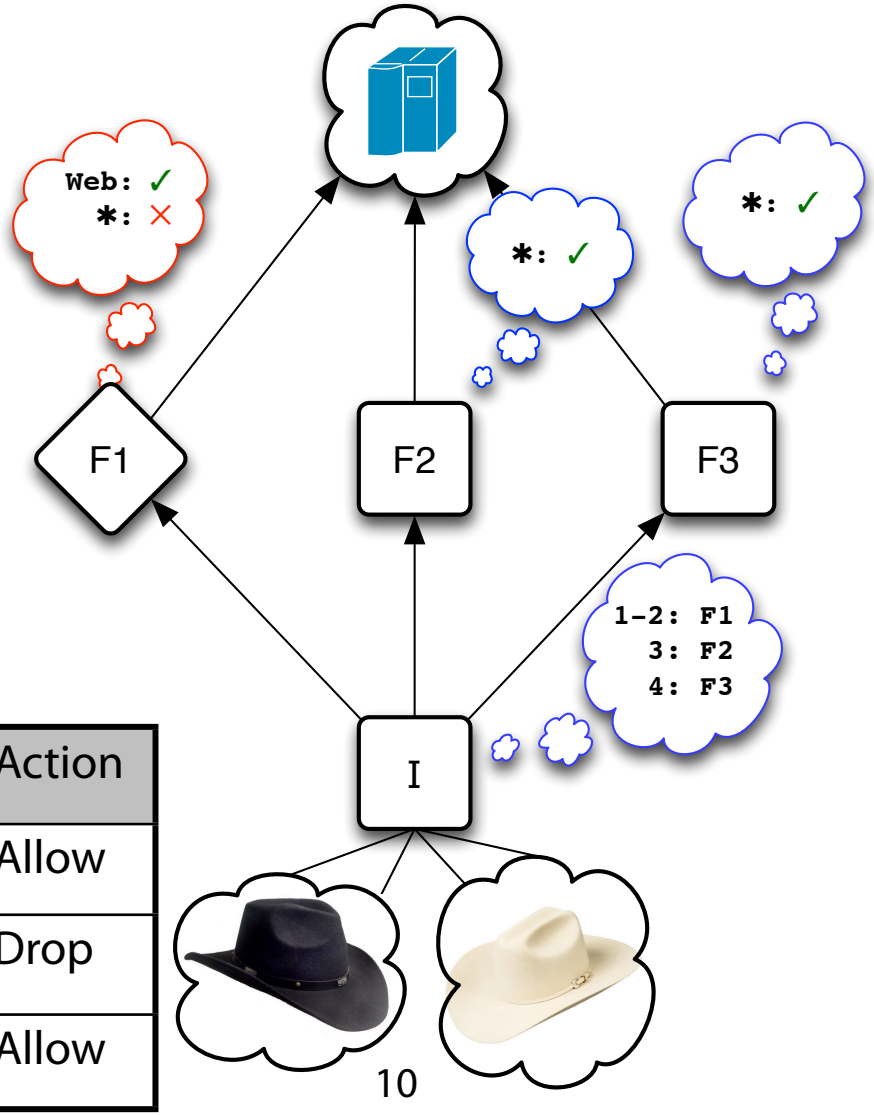
Initial Configuration



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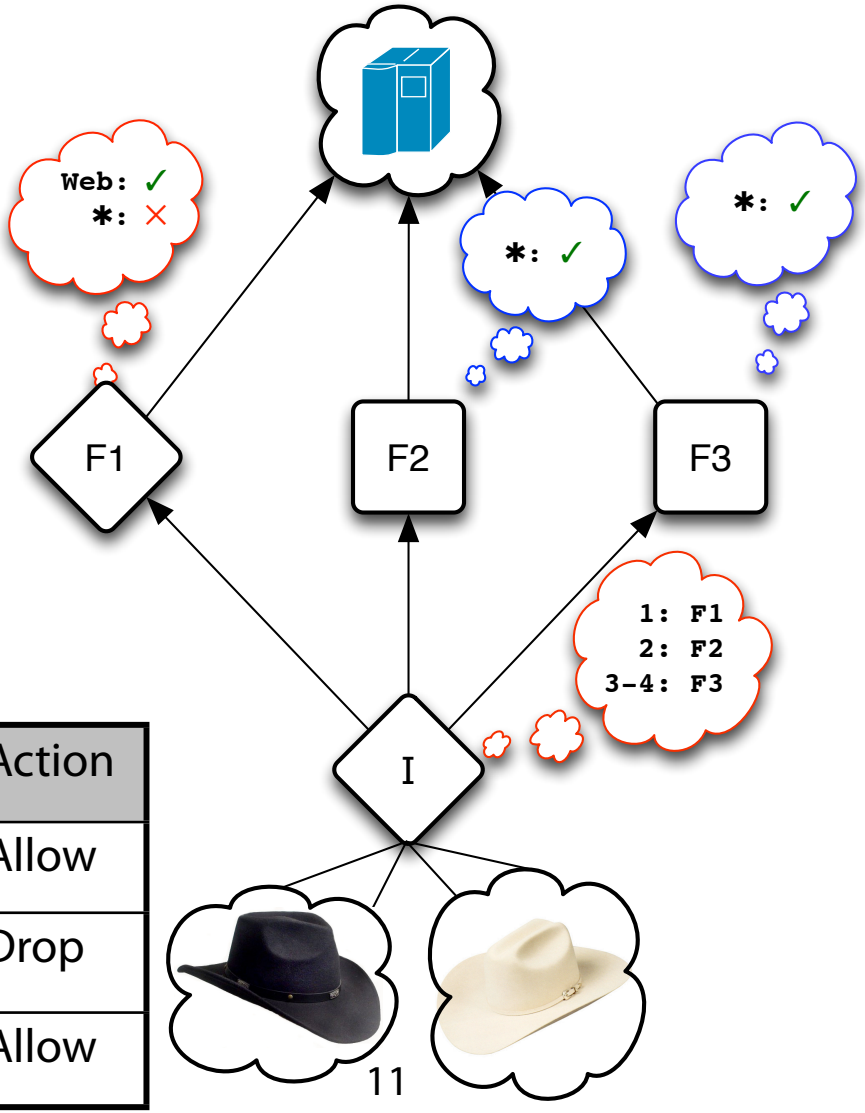
Updating Configuration



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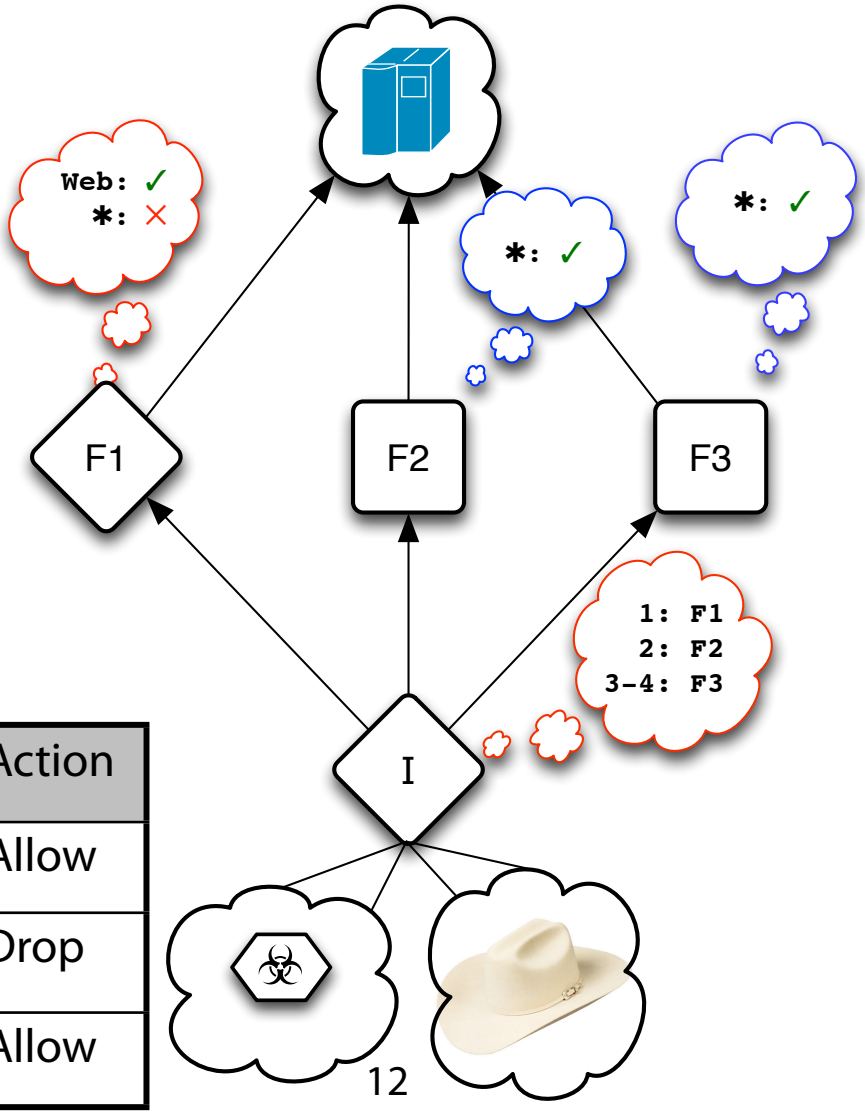
Updating Configuration



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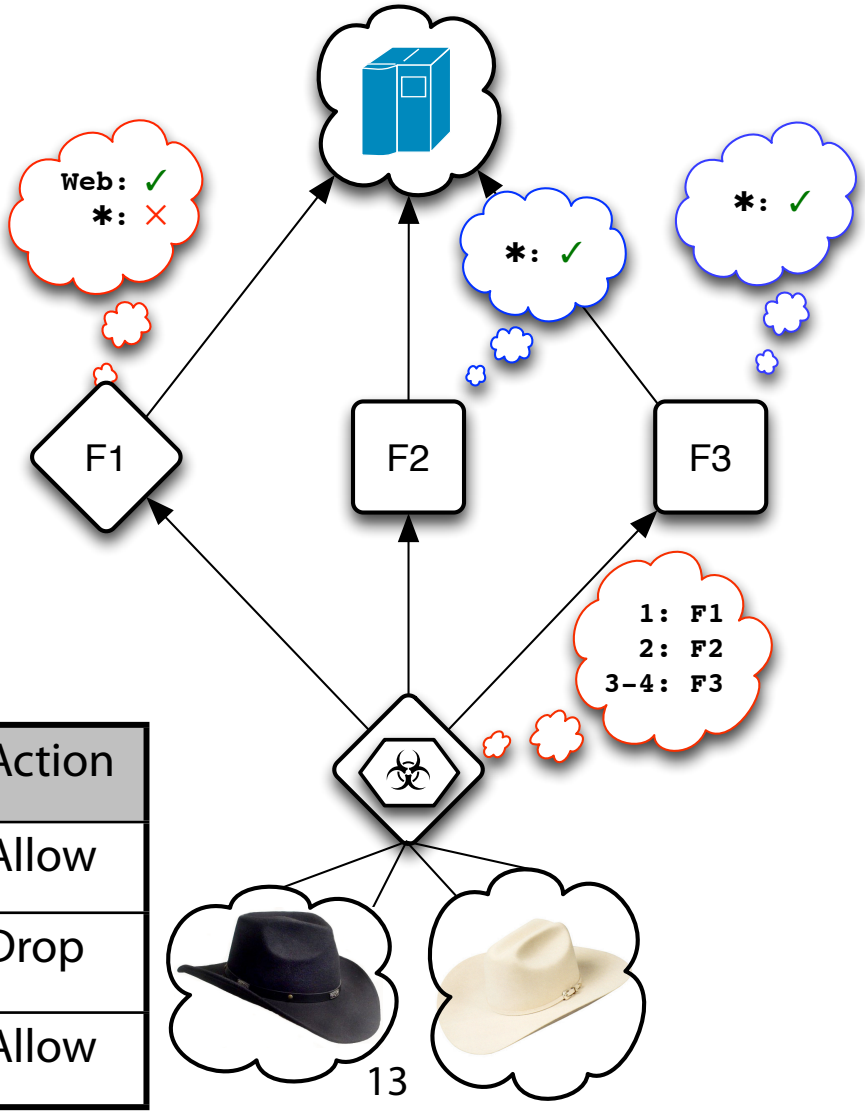
Updating Configuration



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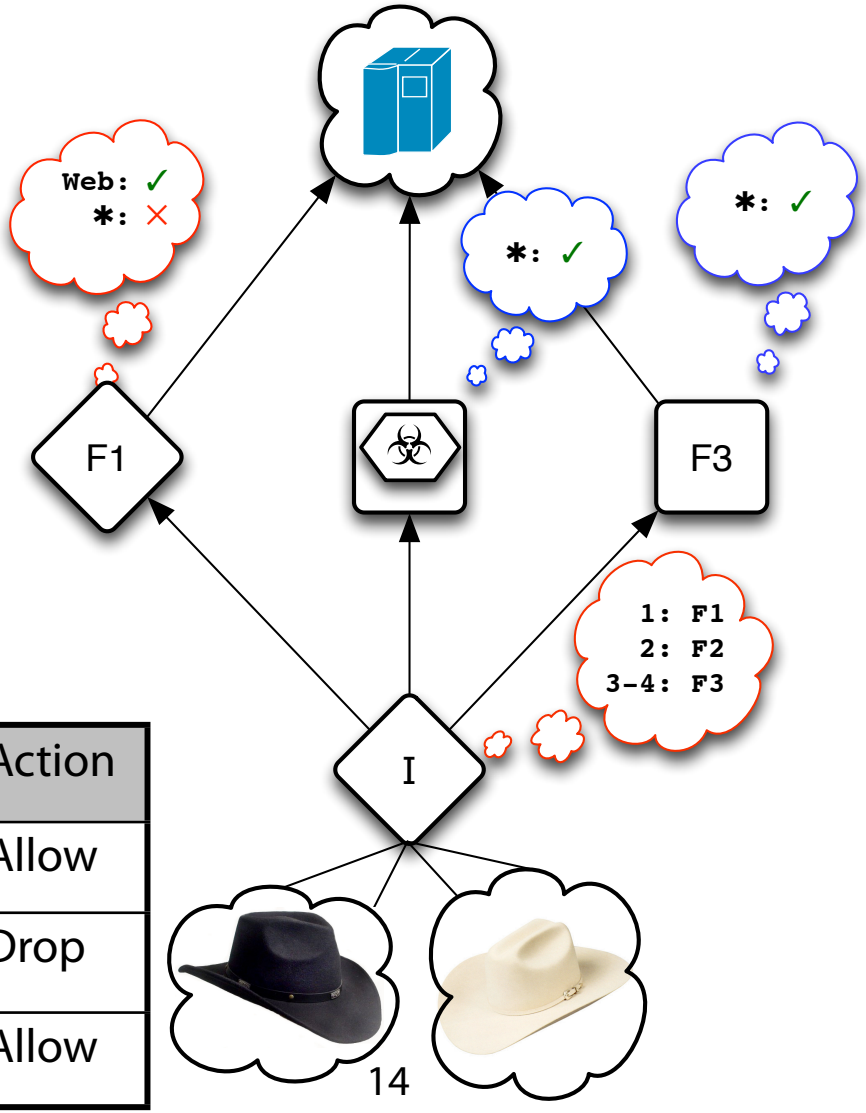
Updating Configuration



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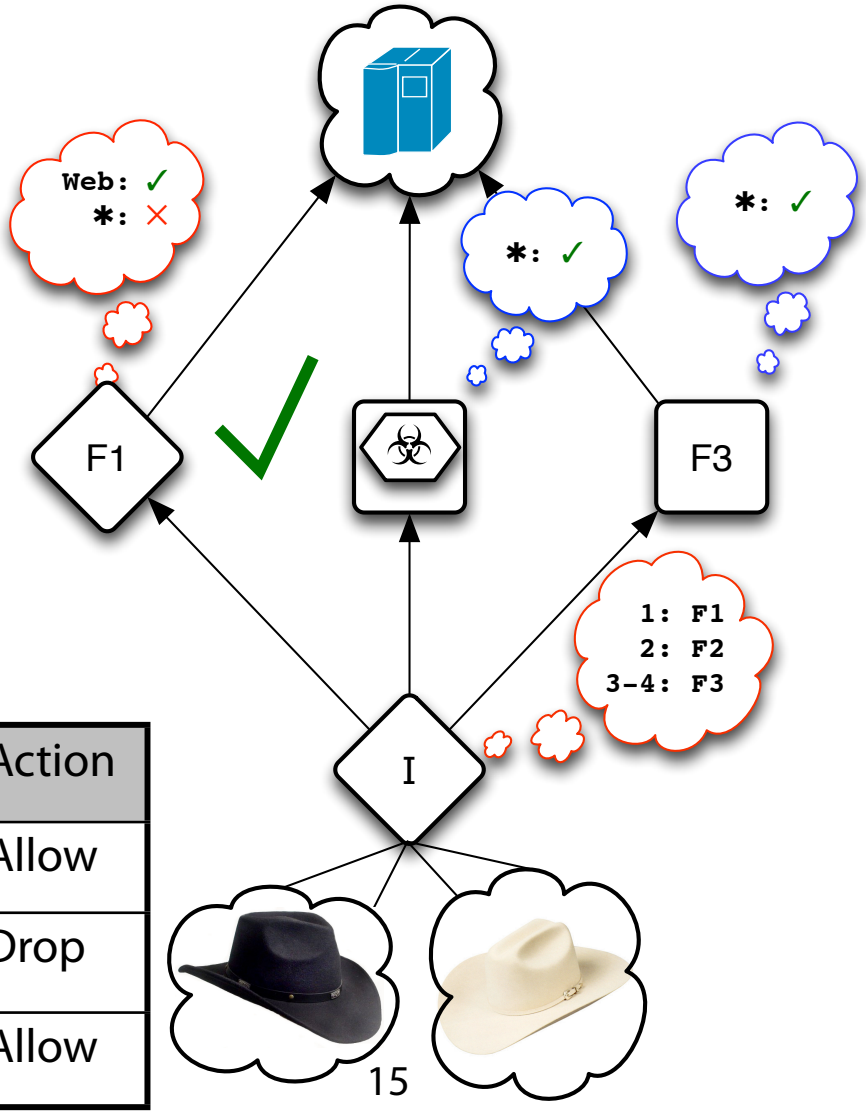
Updating Configuration



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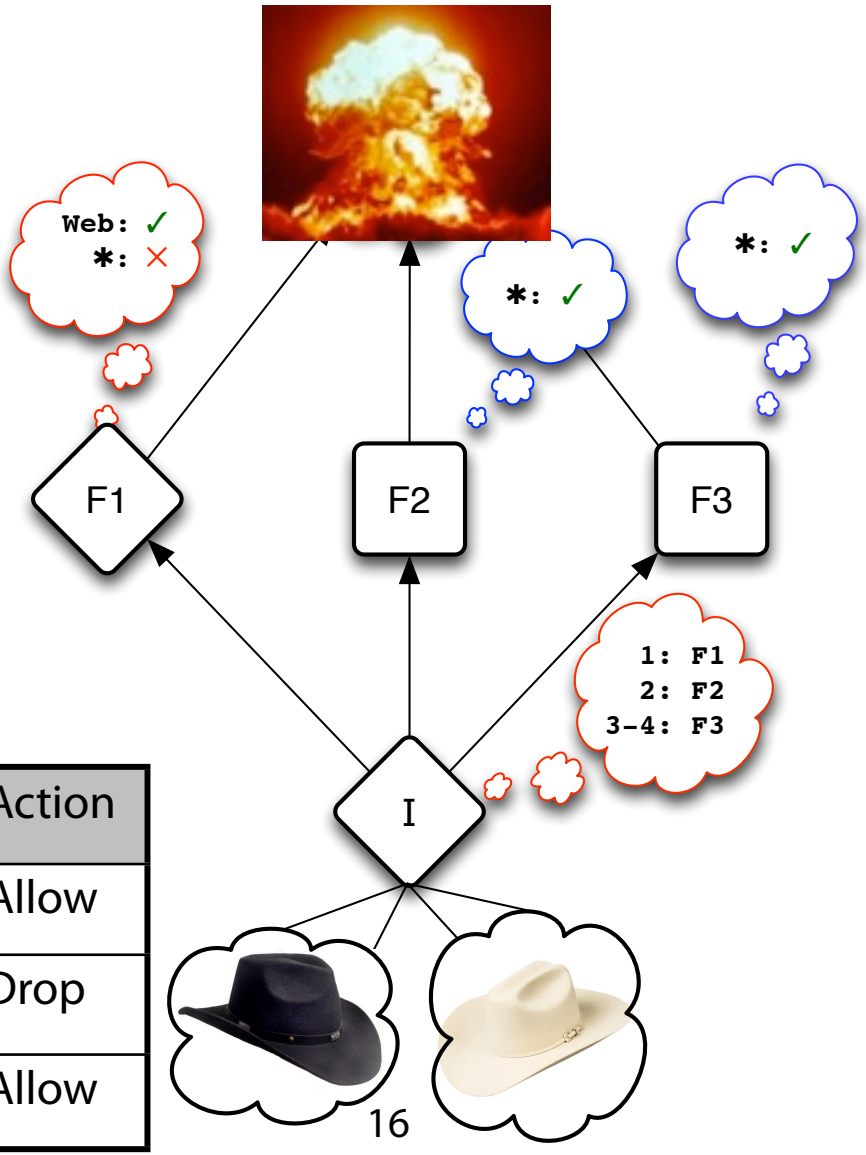
Updating Configuration



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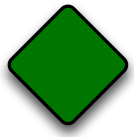
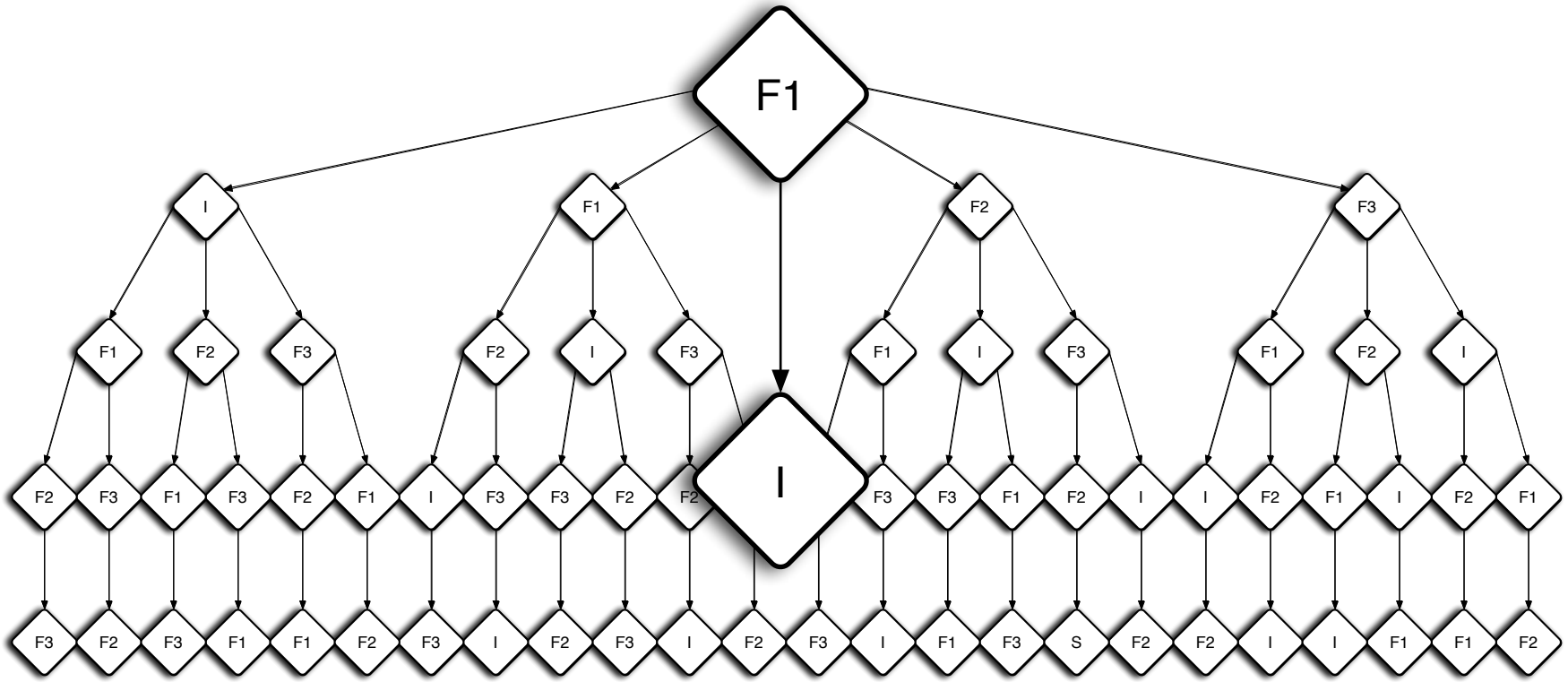
Bad Update Order



Safe

Broken Connectivity

Broken Security



Towards a Solution

Updating individual switches doesn't work!

What's the solution?

- Don't implement updates rule-by-rule and switch-by-switch!
- Leverage the run-time system to handle tedious, low-level details

SDN Program

```
void main() {
... monitor ...
Conf = balance_load();
install(Conf);
}
```

Per-packet Consistency

An update from configuration A *to configuration* B *is* **per-packet consistent** *if each packet is routed according to either configuration* A *or* B.

Path Properties

*A **path property** ϕ specifies the legal paths that a packet can take through a network* **N**.

Formally: $\phi \subseteq$ **Packet** x **Paths(N)**.

- Loop-freedom
- "Block SSH traffic from 10/8"
- "All Web traffic waypoints through switch 5"

SDN Program

```
void main() {
... monitor ...
Conf = balance_load();
install(perpacket, Conf);
}
```

Beyond Path Properties

Not path properties:

- In-order delivery
- Flow affinity

> *An update from configuration* A *to configuration* B *is* **per-flow consistent** *if each packet* ***in the same flow*** *is routed according to either configuration* A *or* B.

See paper for details

2-Phase Implementation

1. Instrument new configuration with version
2. Install instrumented configuration, leaving all old ingress rules active
3. Activate new ingress rules
4. Wait for old version packets to leave
5. Uninstall old configuration

Future Work

Implementation

- Naive prototype running
- Exploring performance optimizations

Unplanned Change

- Highly responsive
- Weaker consistency

Formal Verification

- Specification language for path properties
- Configuration verifier

Ongoing Work

frenetic ≫

- **This paper**
  Network write abstraction
- **PRESTO ’10, ICFP ’11**
  Network read abstraction
- **POPL ’12**
  Rich policy abstraction

Questions?

Thank You

http://frenetic-lang.org

Database Analogy

Network	Database
Fully routed packet	Read Transaction
Single hop routed packet	Read
Network update	Write Transaction
Single switch update	Write
Per-Packet Consistency	Snapshot Isolation