facebook

Robotron: Top-down Network Management at facebook Scale

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Scale of Facebook Community

1.7 Billion

on Facebook Monthly

1 Billion

on Whatsapp Monthly

500 Million

on Instagram Monthly

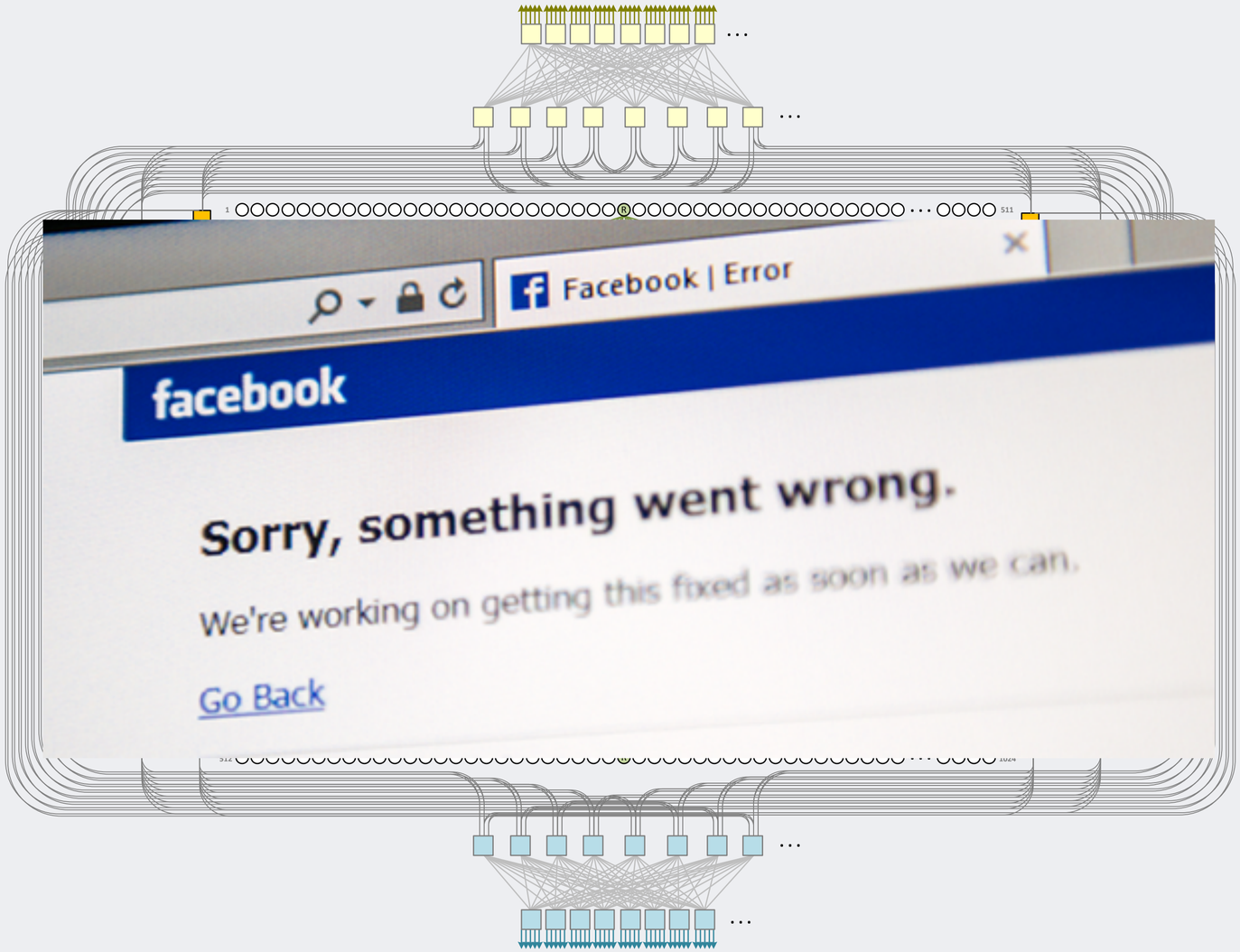
1 Billion

on Messenger Monthly

Network Management at Facebook

What's involved?

- Goals: Build and evolve FB network
- Example tasks: circuit/device turnup, network monitoring
- Human interactions -> outages



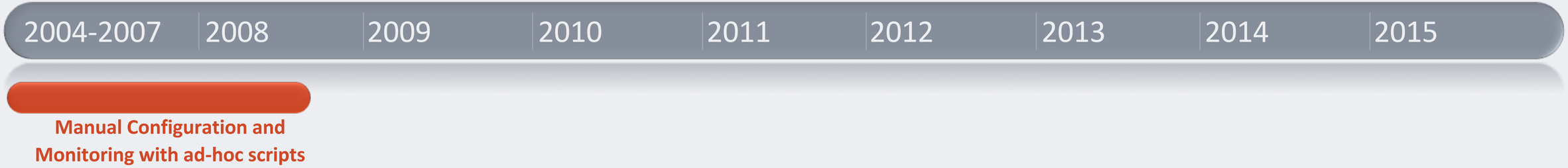
Network Management at Facebook

Why is it hard?

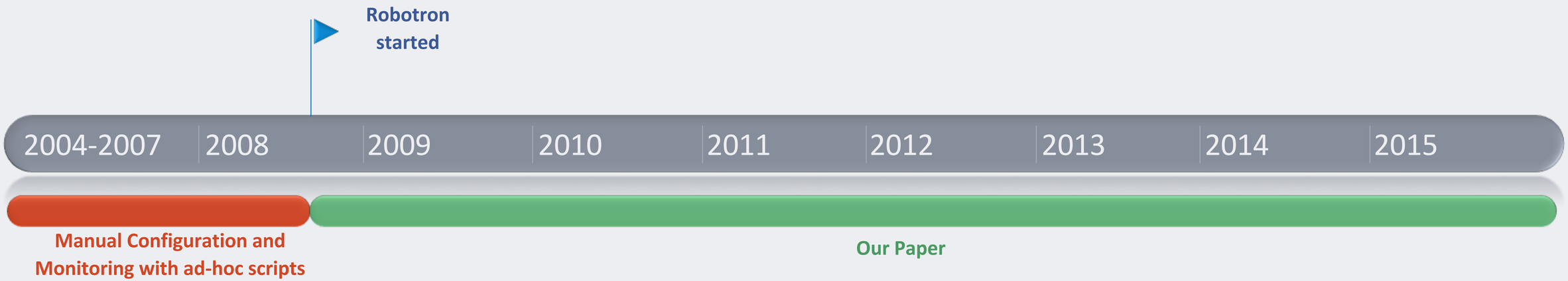
- Distributed Configurations
- Multiple Domains
- Versioning
- Dependency
- Vendor Differences

Network Management at Facebook

Early days…



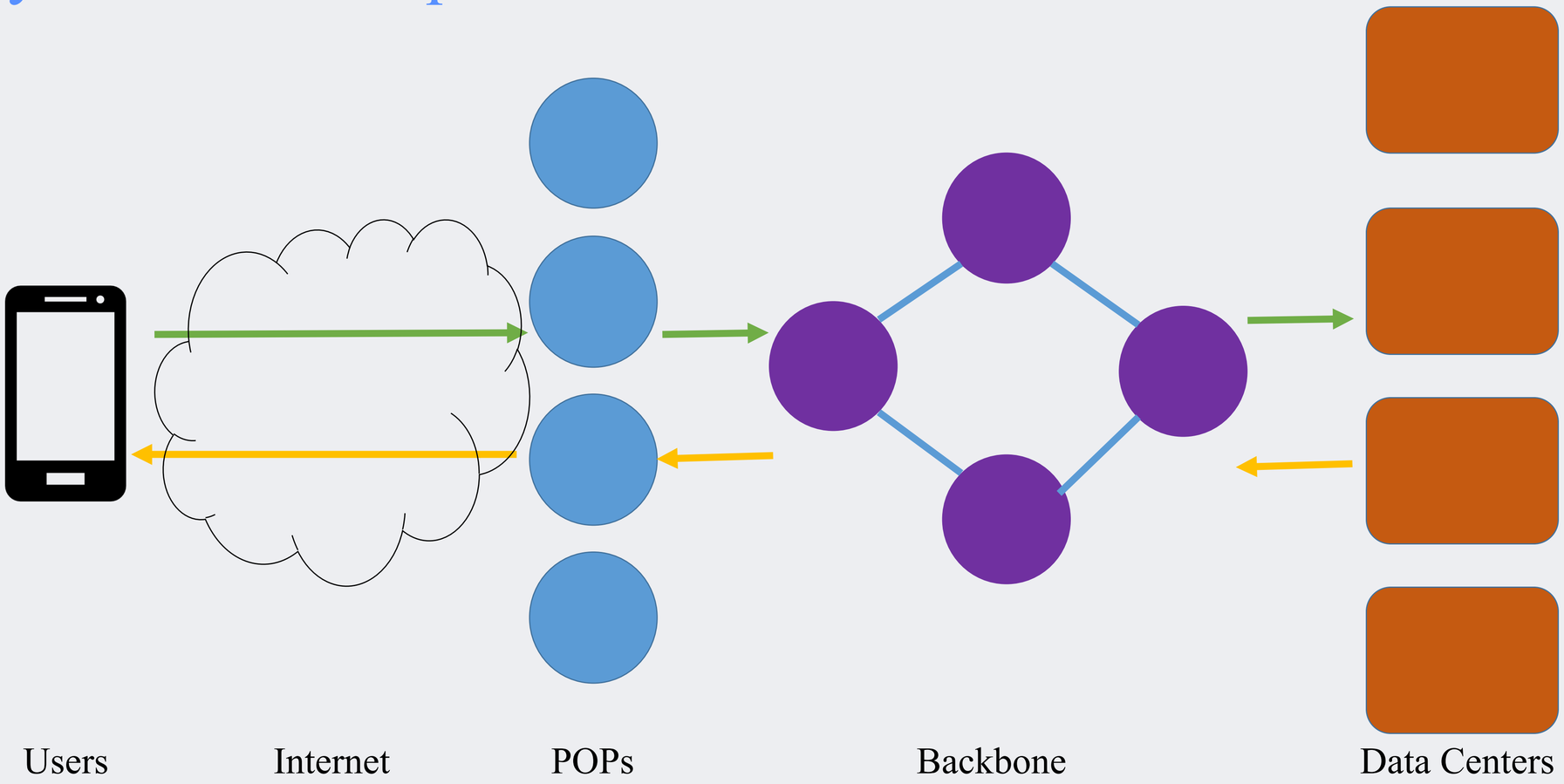
Contribution



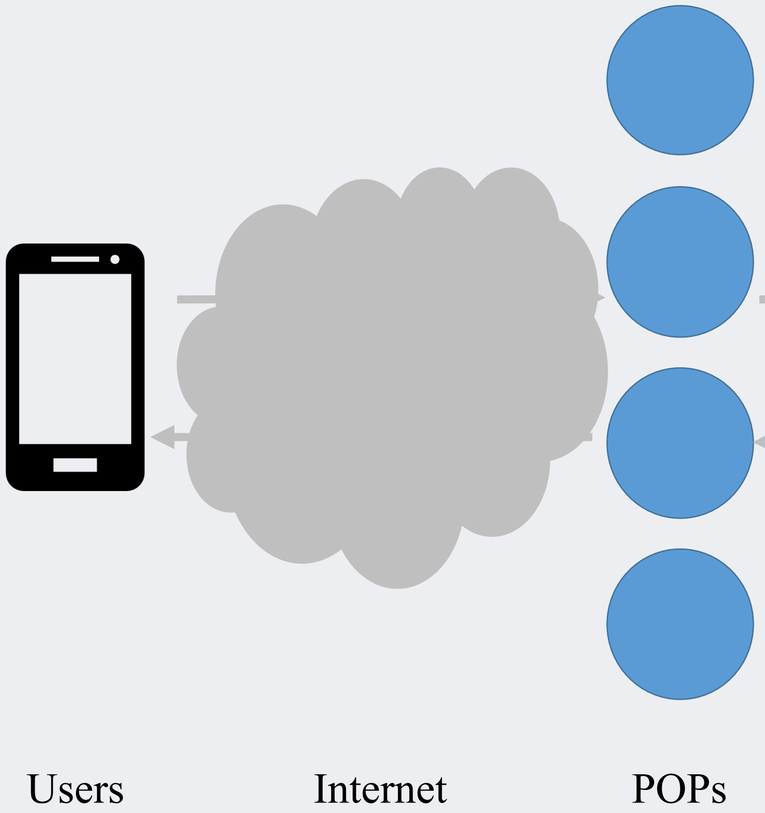
- Shed light on
  - Network management tasks
  - Robotron’s usage
  - Evolution of Roboron
  - Our experiences using Robotron

Overview of Facebook's Network

Lifecycle of user requests



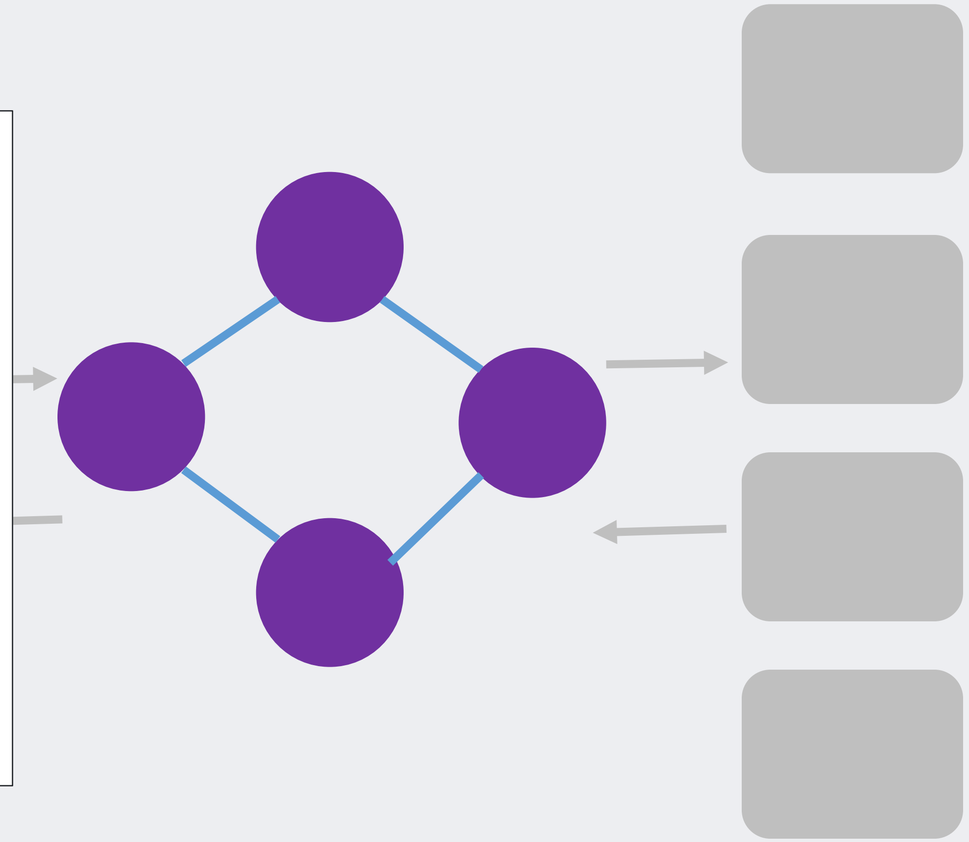
Point of Presence (POP)



- Standardized topology
- Services: LB, Cache
- Common tasks
  - Build/upgrade a cluster
  - Provisioning new peering circuits

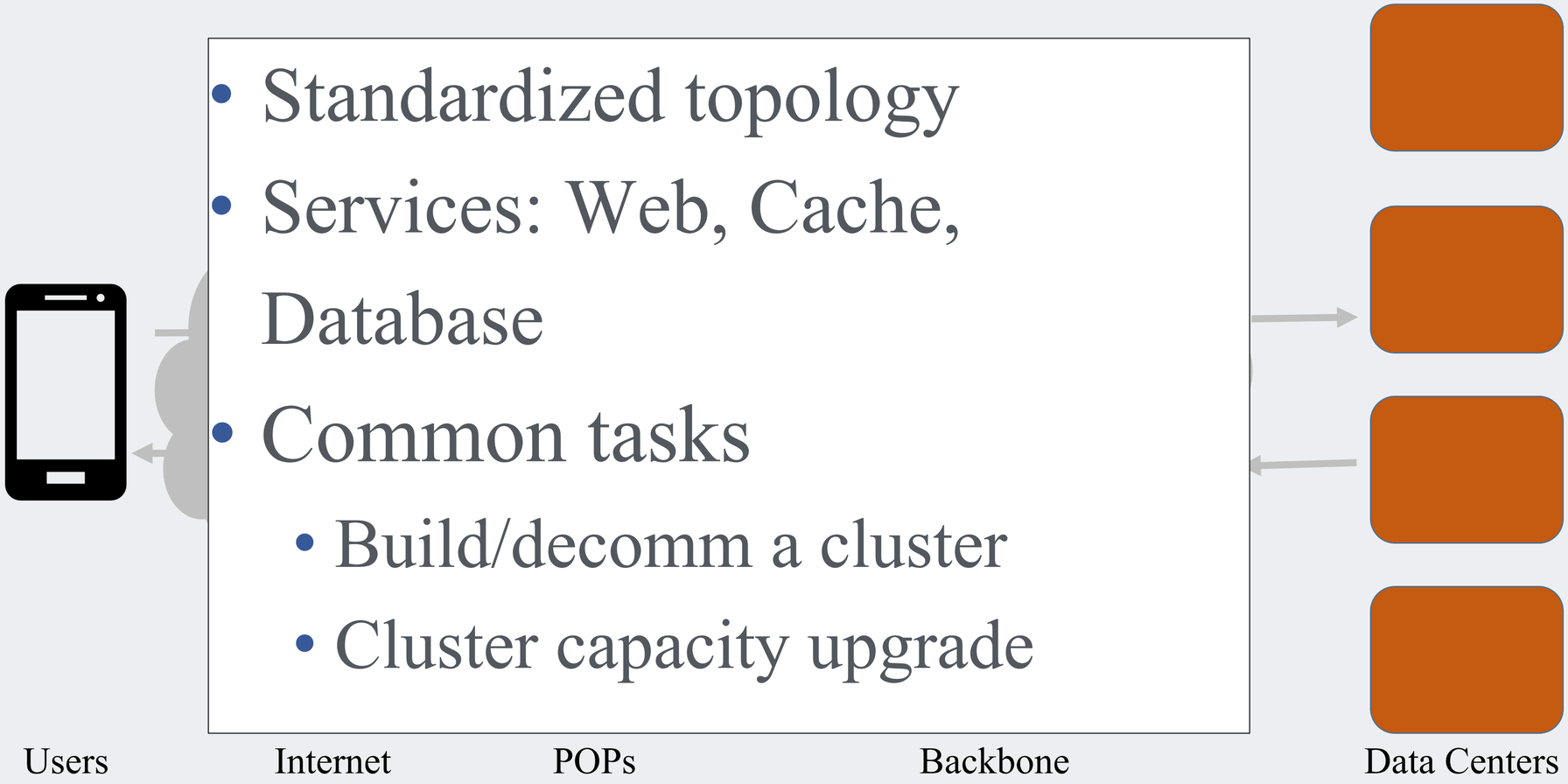
Backbone

- Irregular, demand-driven topology
- Common tasks:
  - Add/migrate circuits
  - Add/remove routers



Users Internet POPs Backbone Data Centers

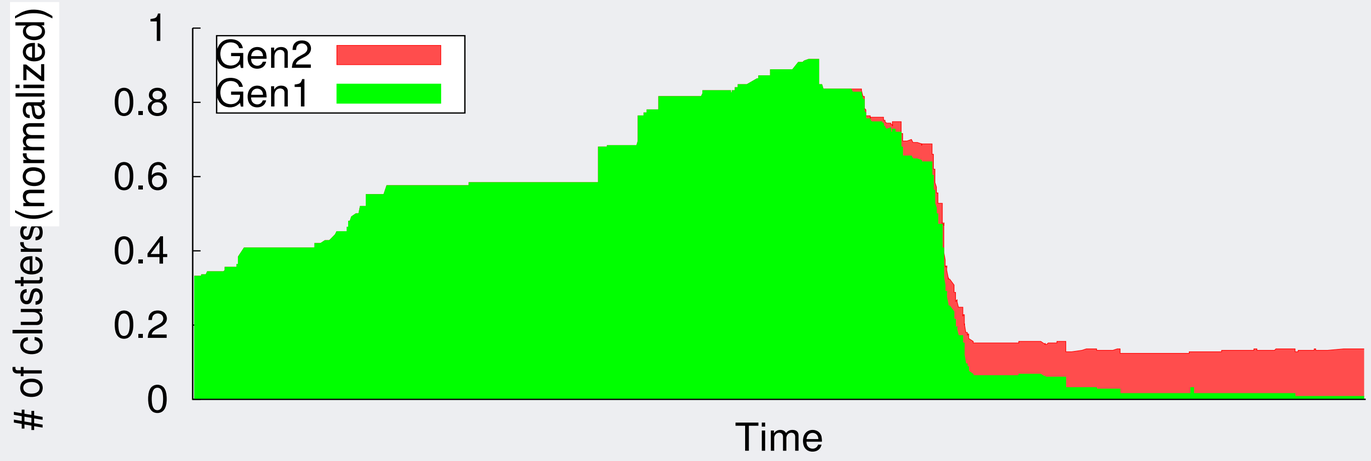
Datacenter


Standardized topology
Services: Web, Cache,
Database
Common tasks
Build/decomm a cluster
Cluster capacity upgrade
Users
Internet
POPs
Backbone
Data Centers

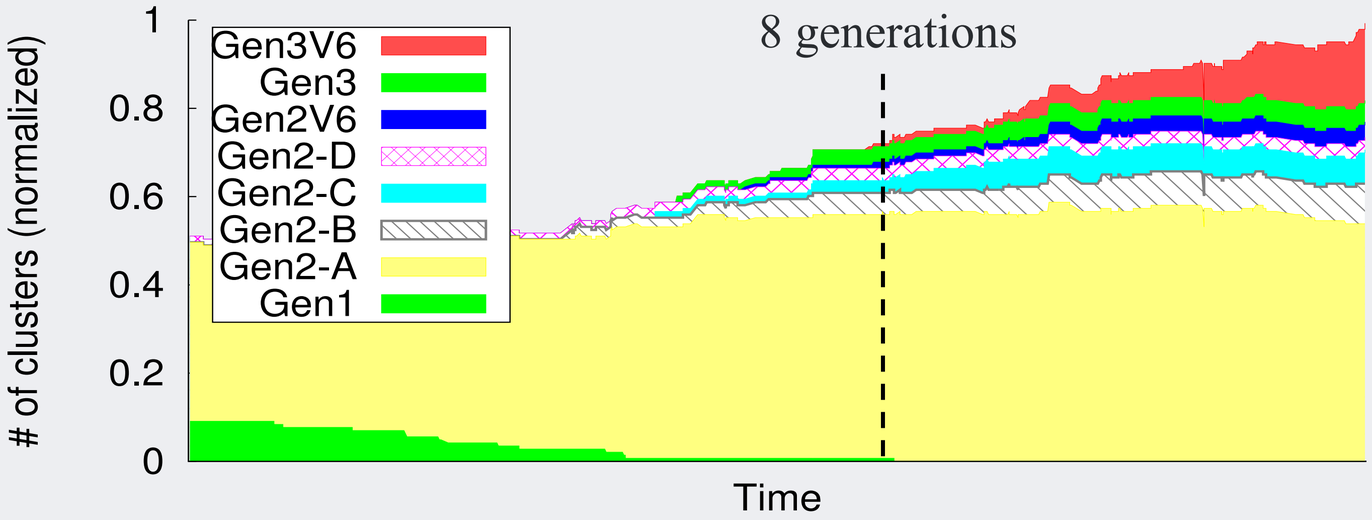
Overview of Facebook's Network

Multiple versions of FB cluster architectures co-exist

POP

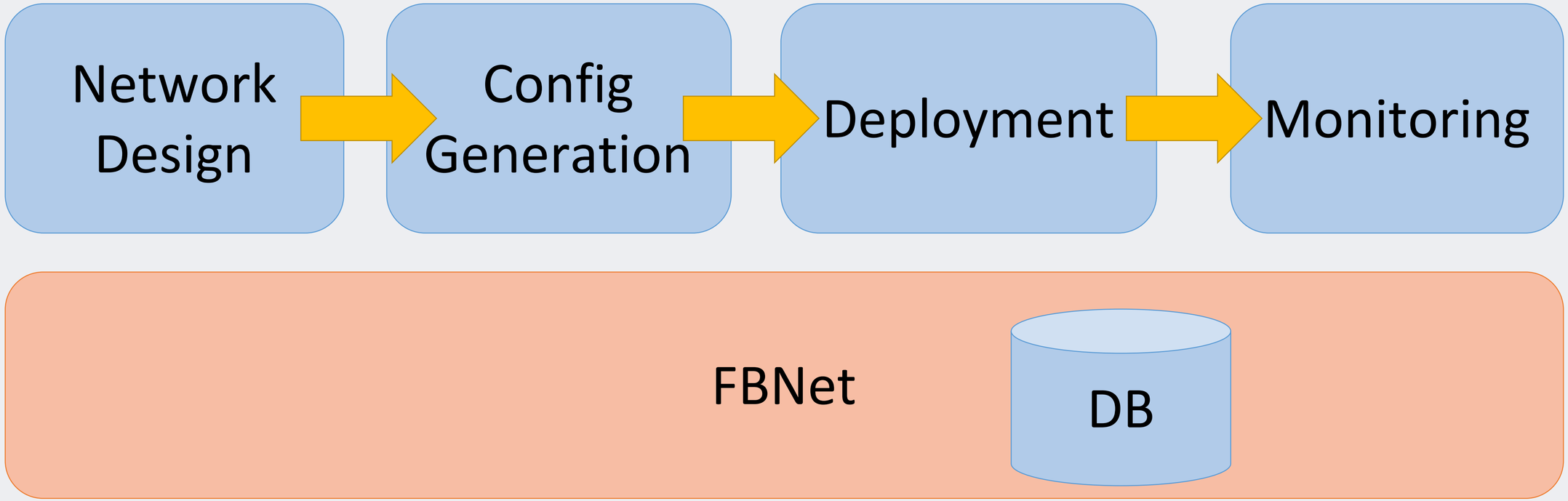


DC



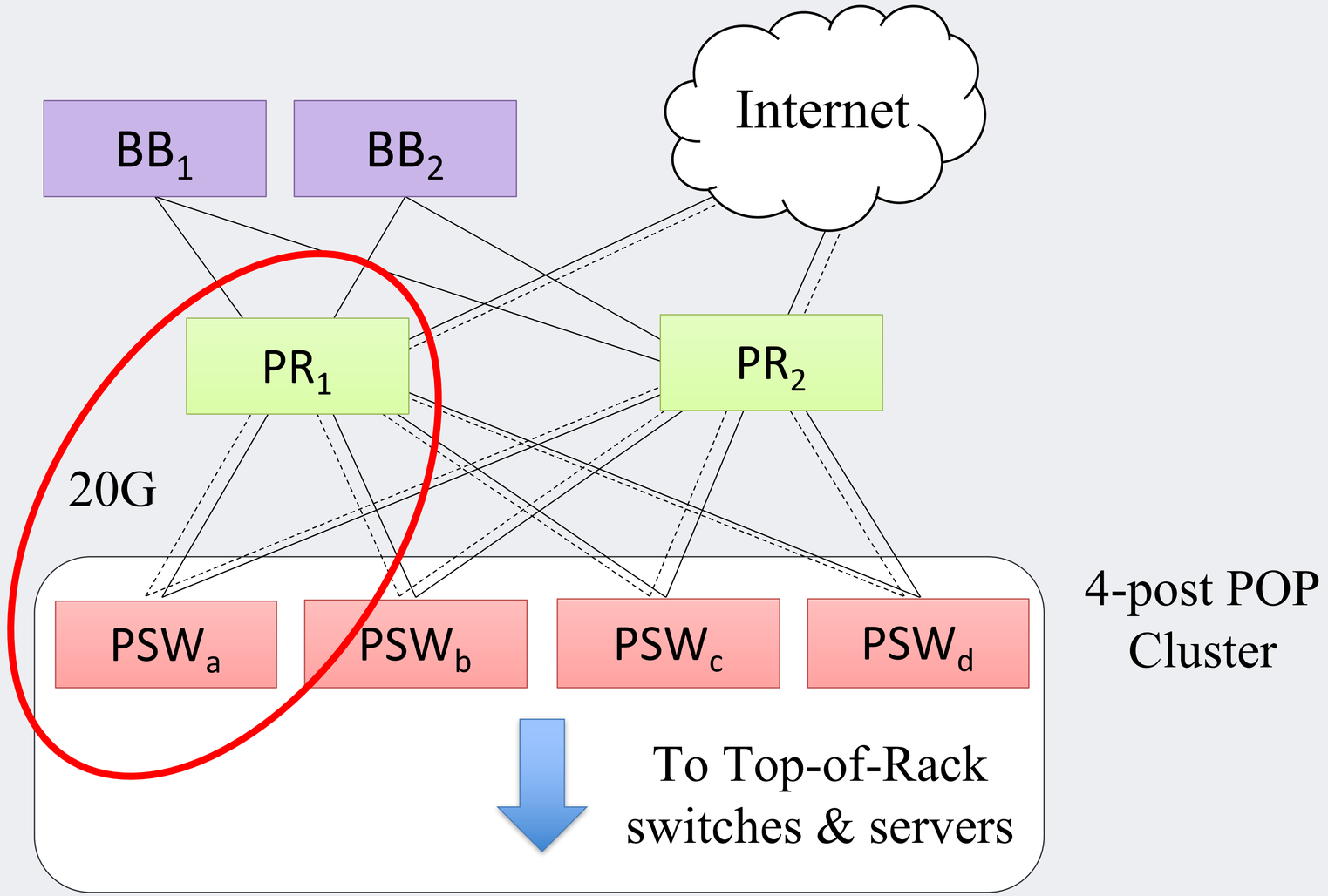
Robotron: “Top-Down” Network Management System@FB

Overview



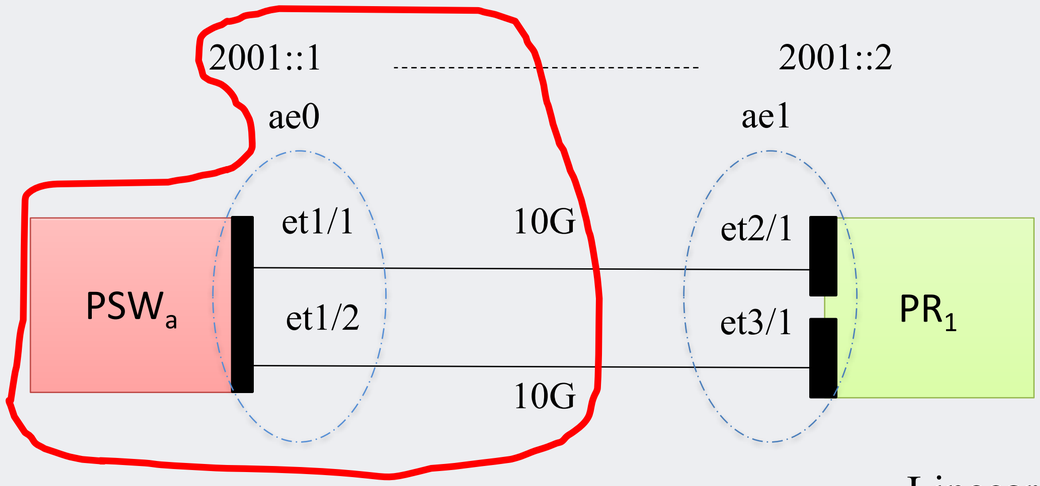
FBNet: Modeling the Network

Example 4-post POP cluster



FBNet: Modeling the Network

Object



eBGP session

Linecard

Circuit

Networkswitch

Linecard

PhysicalInterface

PhysicalInterface

Circuit

AggregatedInterface

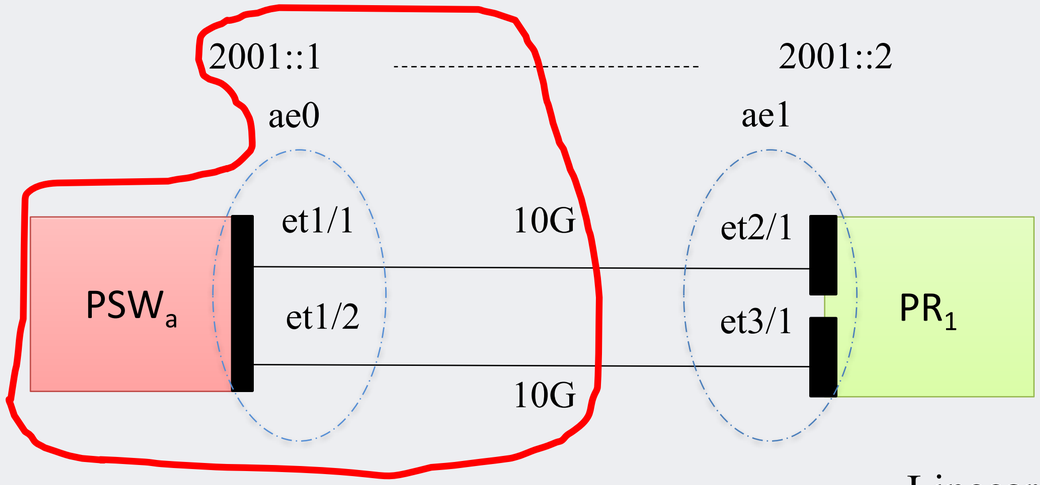
V6Prefix

BgpV6Session

Circuit

FBNet: Modeling the Network

Value



Networkswitch

name=PSW$_a$

Linecard

slot=1
model=X

PhysicalInterface

name=et1/1

PhysicalInterface

name=et1/2

AggregatedInterface

name=ae0

V6Prefix

prefix=2001::1

Circuit

speed=10G

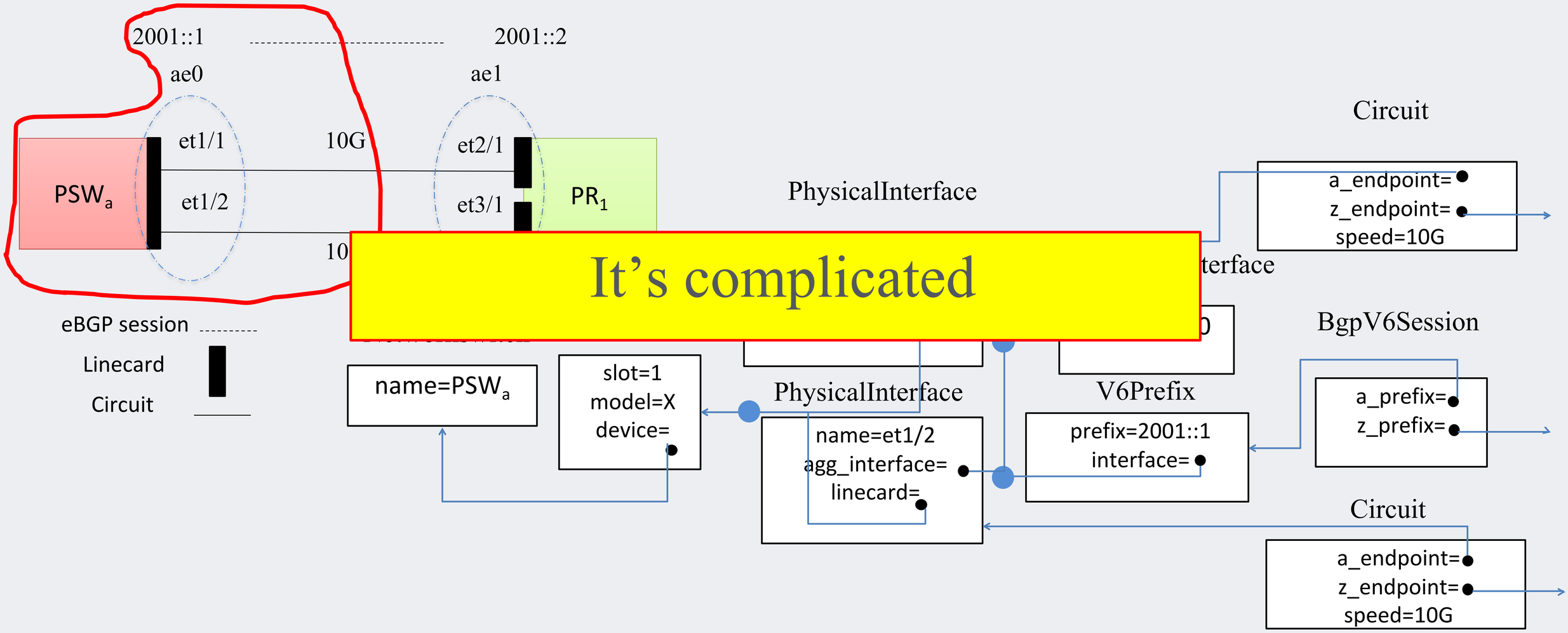
BgpV6Session

Circuit

speed=10G

FBNet: Modeling the Network

Relationship



FBNet Model Snippet

```
class PhysicalInterface(Interface):
  linecard = models.ForeignKey(Linecard)
  agg_interface = models.ForeignKey(
      AggregatedInterface)
```

FBNet Model Snippet

Related models

```
class PhysicalInterface(Interface):
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```

FBNet Model Snippet

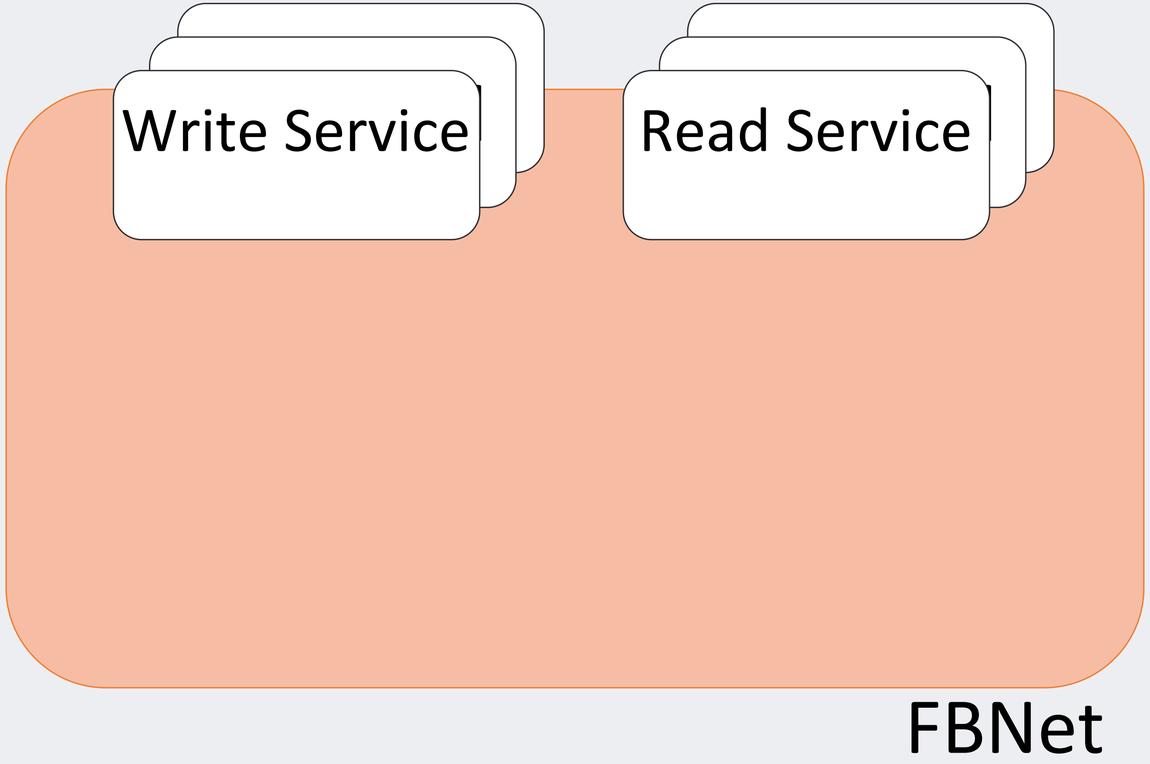
Model inheritance

```
class PhysicalInterface(Interface):
  linecard = models.ForeignKey(Linecard)
  agg_interface = models.ForeignKey(
      AggregatedInterface)
```

FBNet: Architecture

API Layer

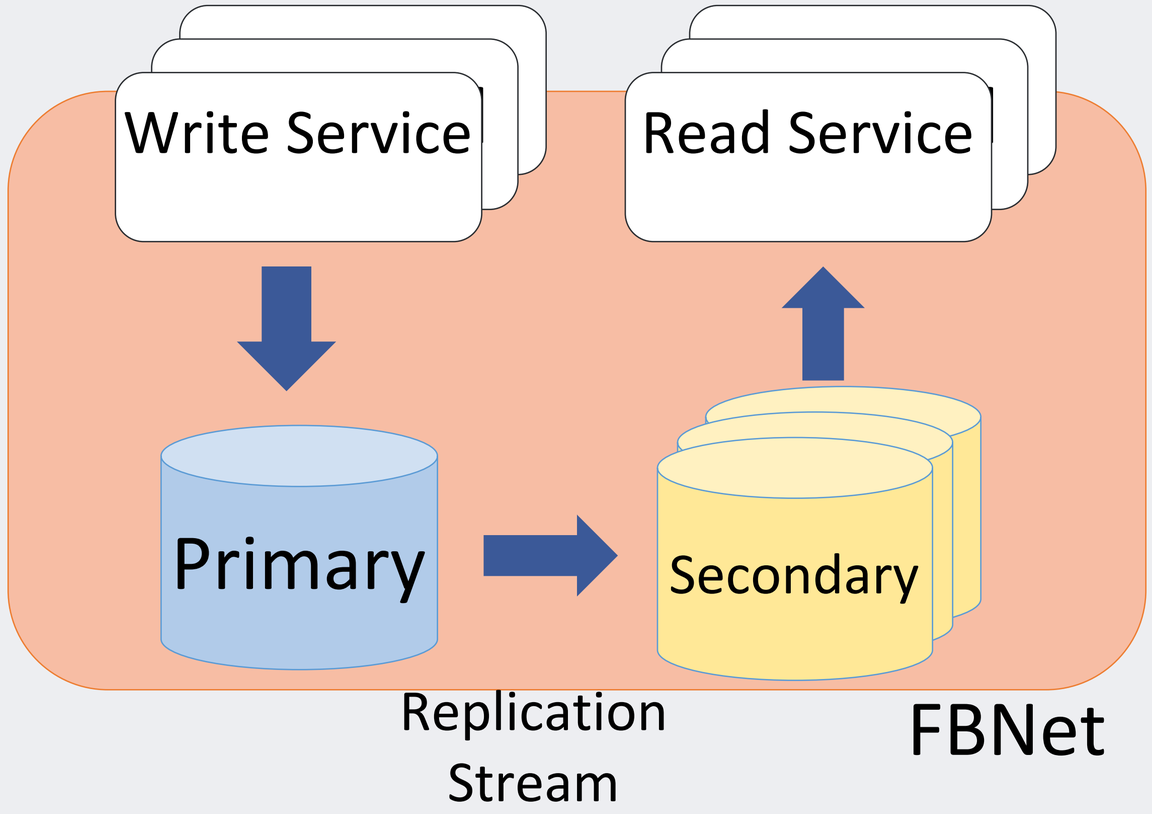
- RPC services
  - Read: fine-grained per-model query
  - Write: task-based
- High Availability: Multiple replicas per DC



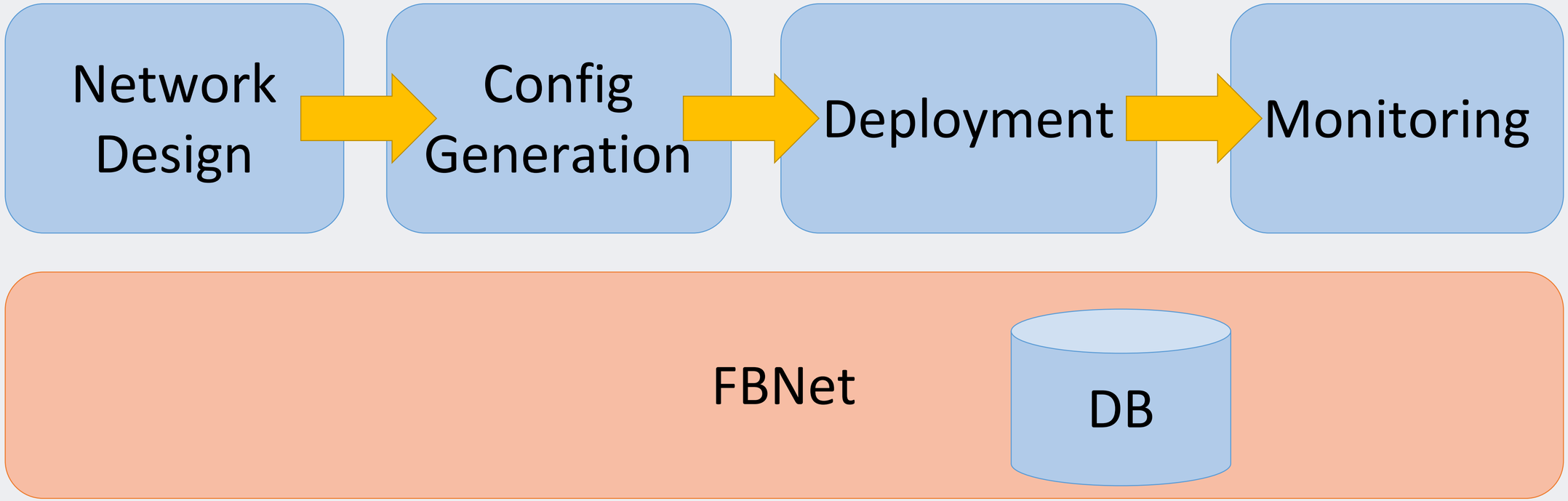
FBNet: Architecture

API Layer

- 1 primary, multiple secondary DBs
- Scalability: 1 slave per DC



Robotron’s management life cycle



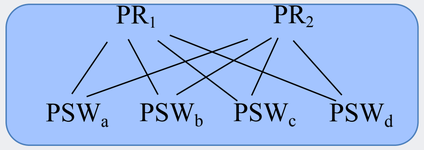
Network Design

Design intent → FBNet objects

Template for a POP cluster

```
Cluster(
   devices={
      PR: DeviceSpec(
         hardware="Router_Vendor1"
         num_devices=2)
      PSW: DeviceSpec(
         hardware="Switch_Vendor2"
         num_devices=4)
   },
   Link_groups=[
      LinkGroup(
         a_device=PR,
         z_device=PSW,
         pifs_per_agg=2,
         ip=V6)
   ]
)
```

FBNet objects



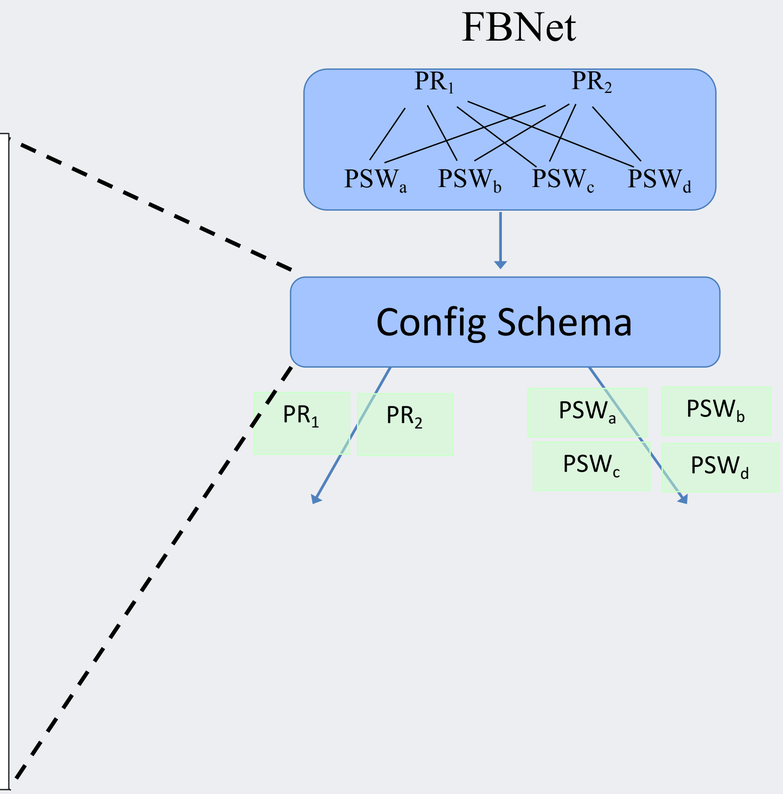
BackboneRouters: 2
NetworkSwitches: 4
Circuits: 16
PhysicalInterfaces: 32
AggregatedInterfaces: 16
V6Prefixes: 16
BgpV6Sessions: 8

94 objects across 7 models

Config Generation

FBNet objects → Device configs

```
struct Device {
  1: list<AggregatedInterface> aggs,
}
struct AggregatedInterface {
  1: string name,
  2: i32 number,
  3: string v4_prefix,
  4: string v6_prefix,
  5: list<PhysicalInterface> pifs,
}
struct PhysicalInterface {
  1: string name,
}
```



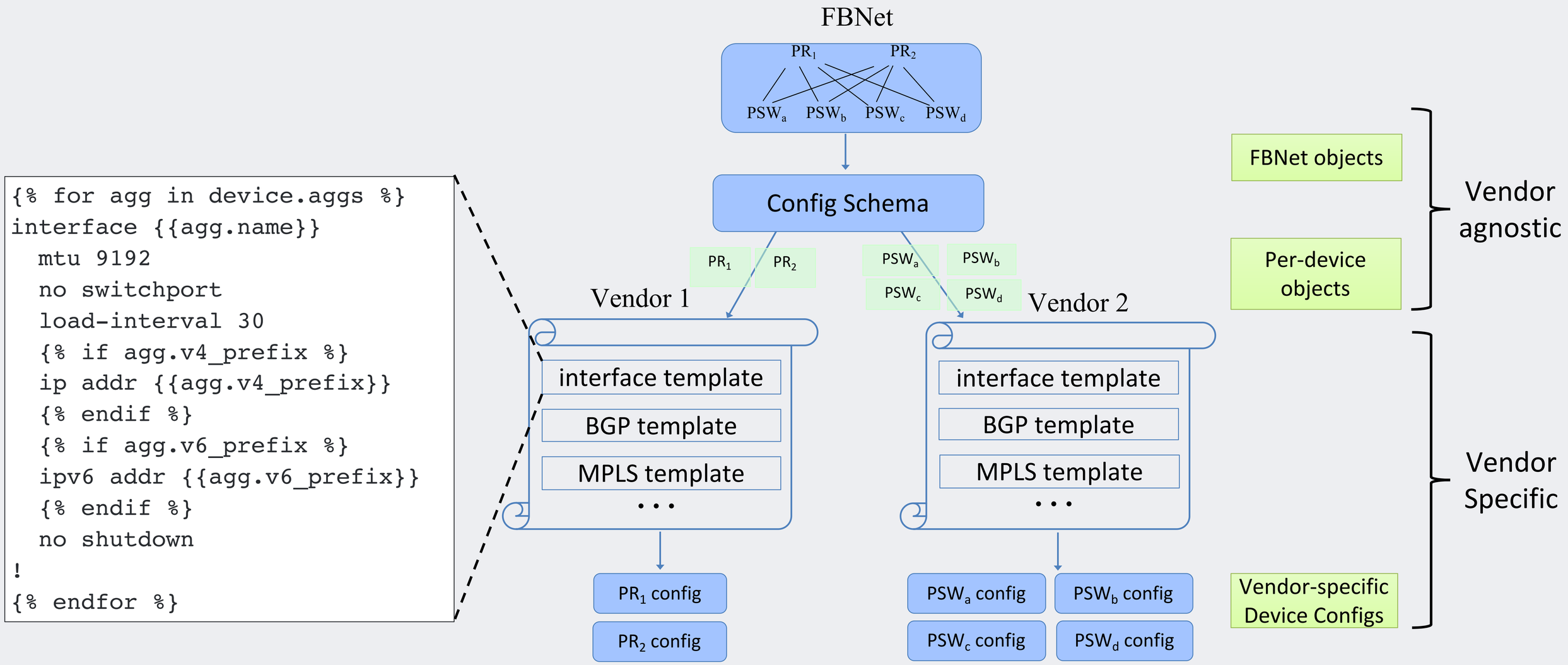
FBNet objects

Per-device objects

Vendor agnostic

Config Generation

FBNet objects → Device configs




```
{% for agg in device.aggs %}
interface {{agg.name}}
  mtu 9192
  no switchport
  load-interval 30
  {% if agg.v4_prefix %}
  ip addr {{agg.v4_prefix}}
  {% endif %}
  {% if agg.v6_prefix %}
  ipv6 addr {{agg.v6_prefix}}
  {% endif %}
  no shutdown
!
{% endfor %}
```

Config Generation

FBNet objects → Device configs

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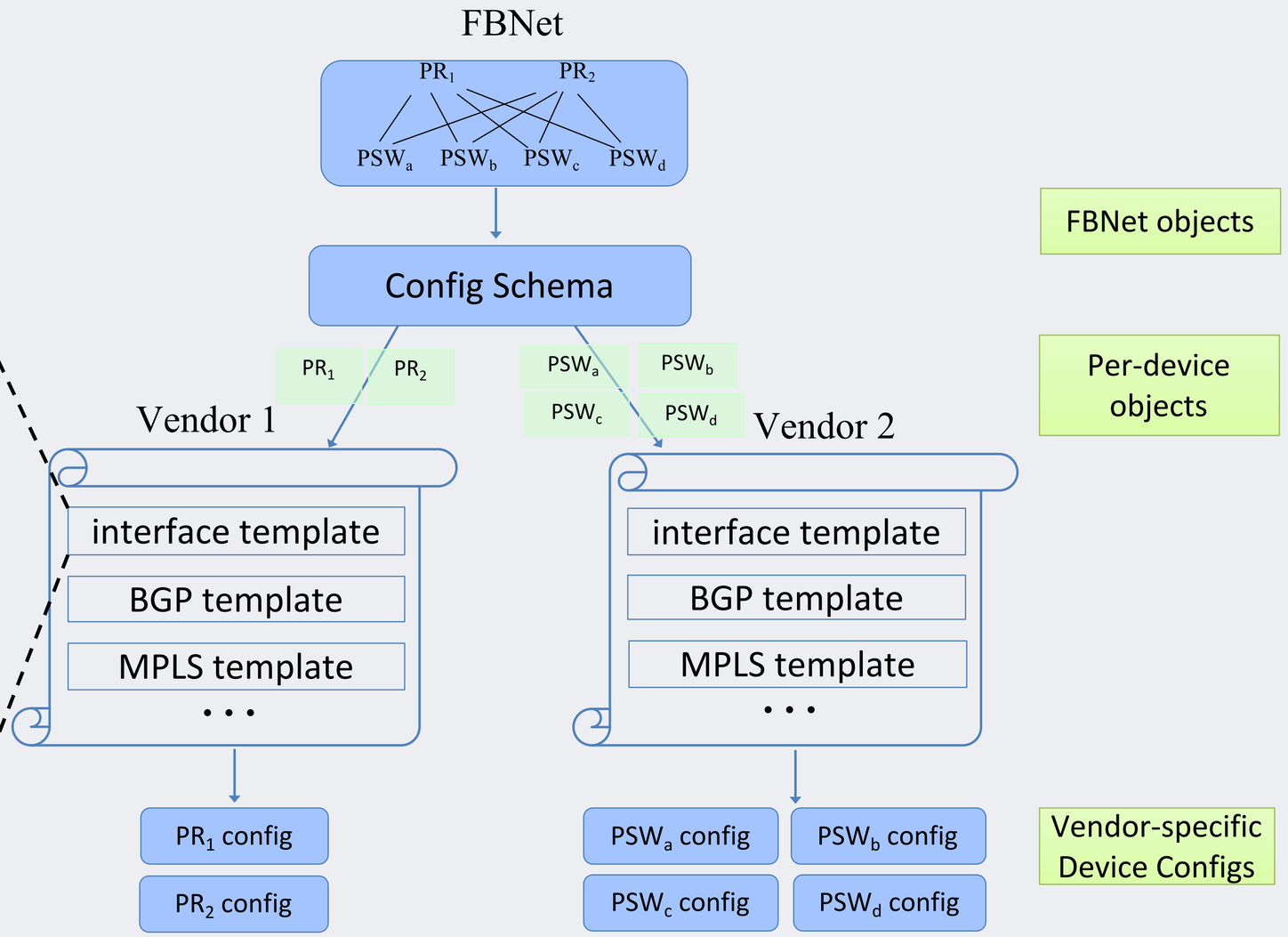

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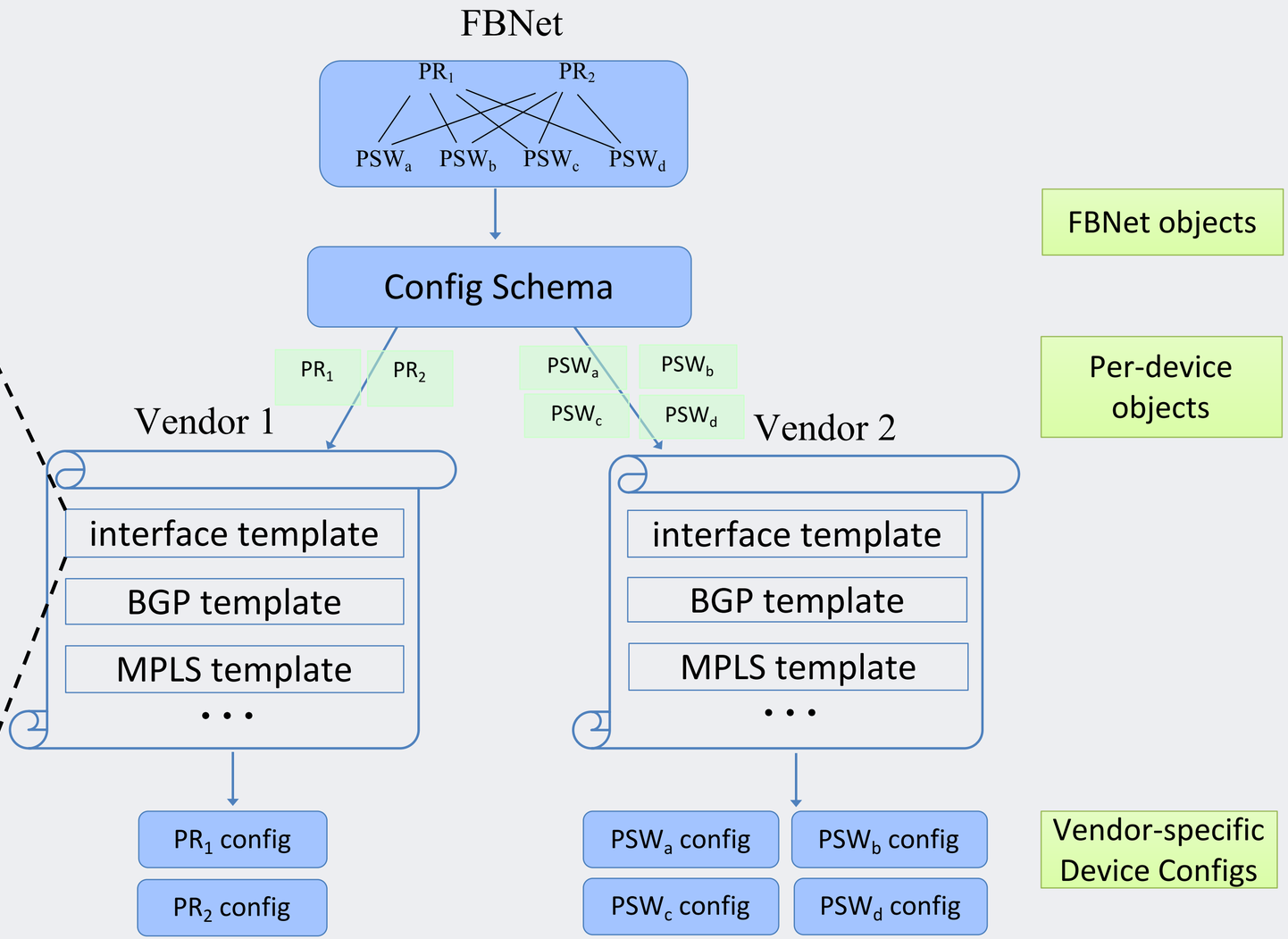

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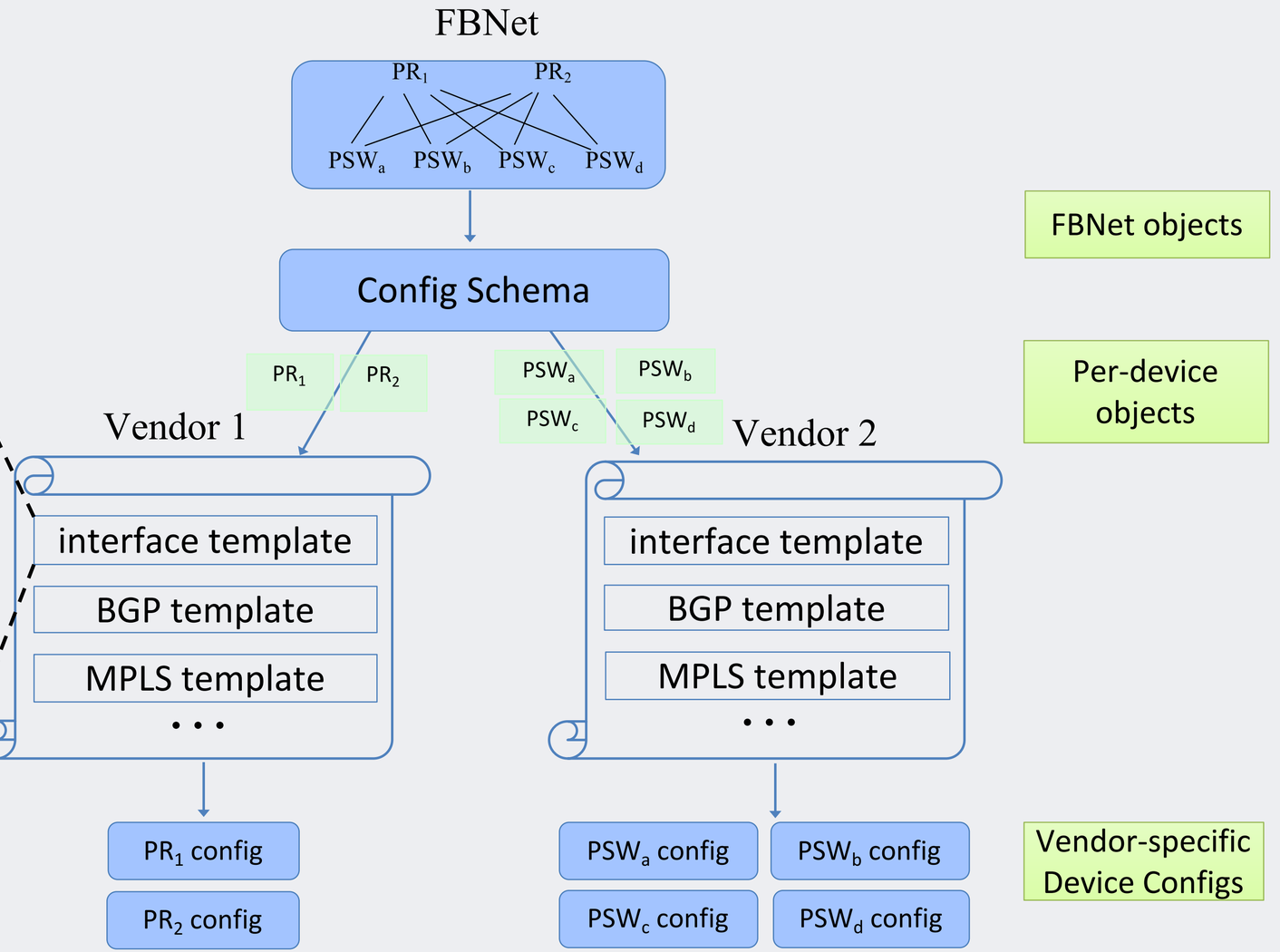
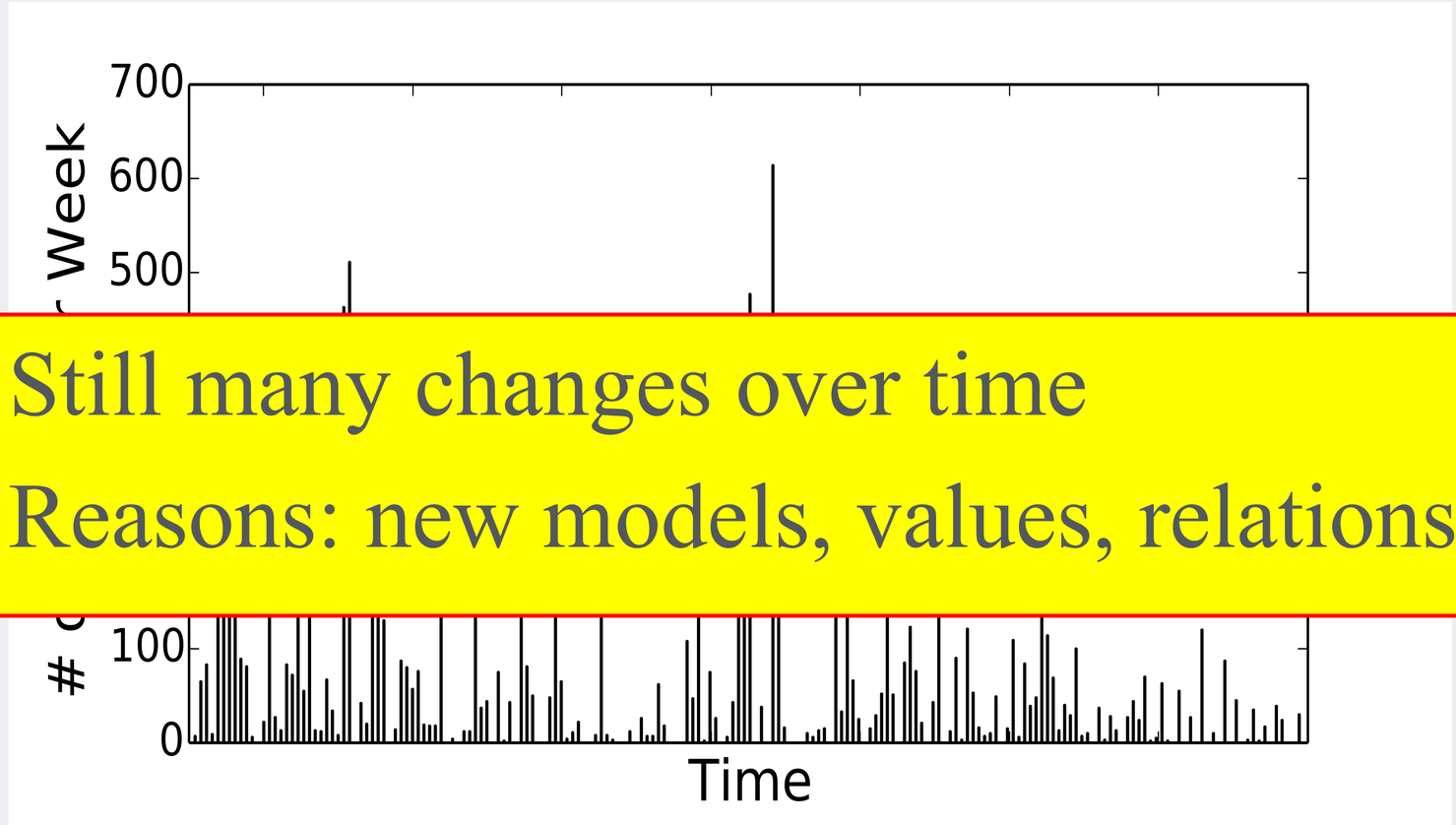


Usage Statistics

- # of FBNet model change?
- # changed FBNet objects per design change?
- Frequency and size of config change?

FBNet Model Changes

How much does FBNet model change over time?

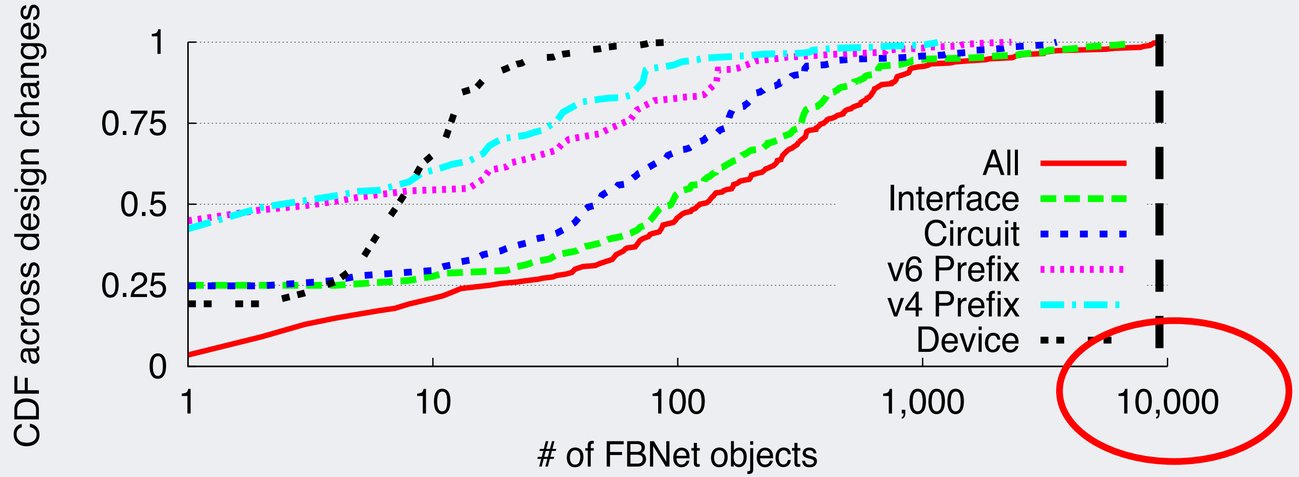


- Still many changes over time
- Reasons: new models, values, relationships

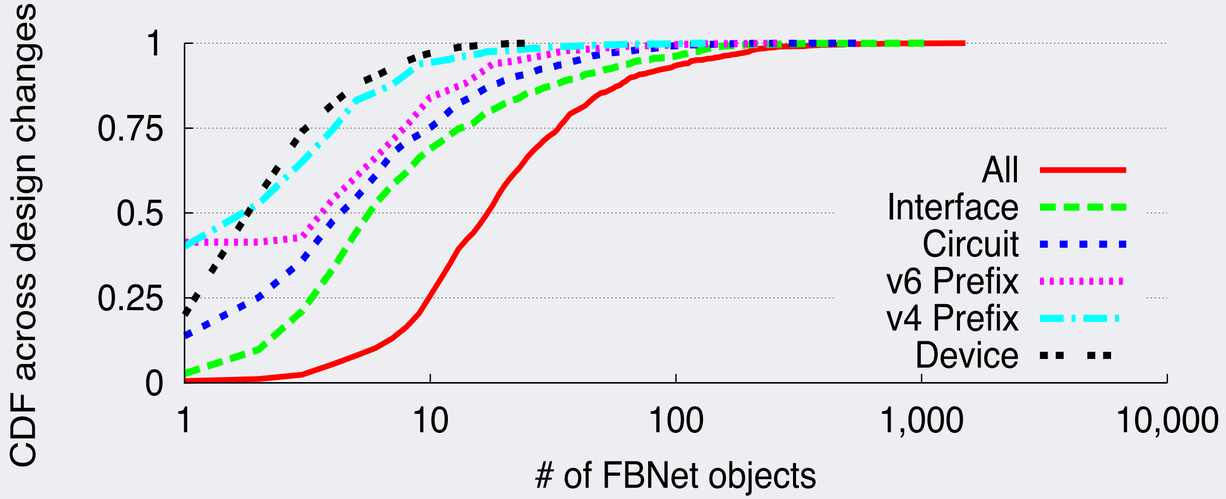
Design Changes

How many FBNet object are changed per design change?

POP/DC



Backbone



Design Changes

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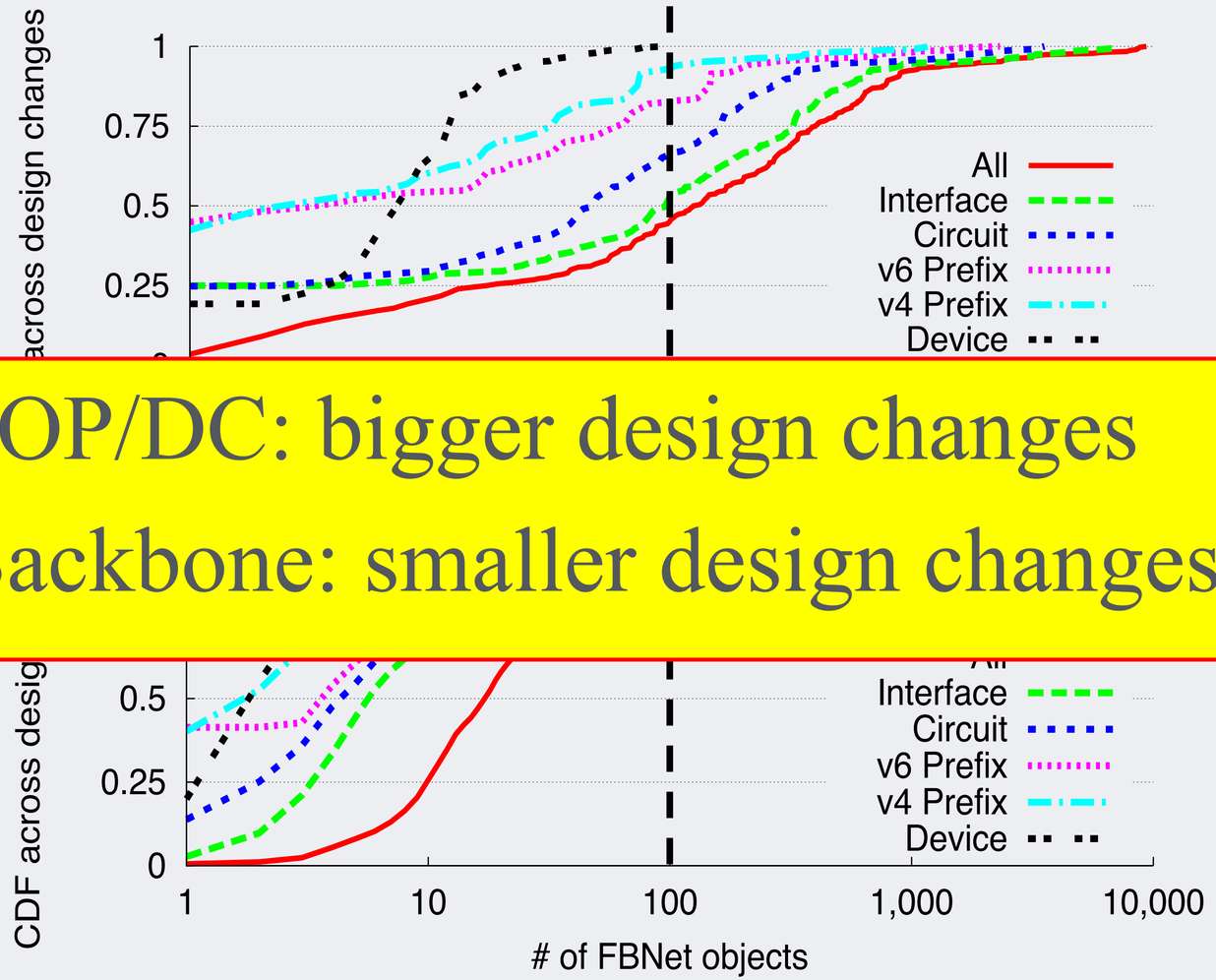
POP/DC

Backbone



- POP/DC: bigger design changes
- Backbone: smaller design changes

Configuration Changes

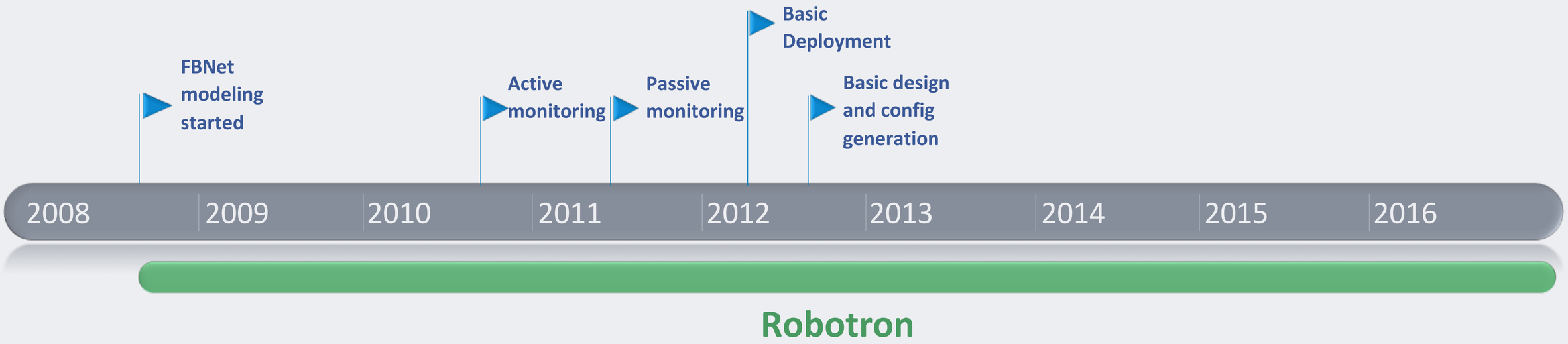
What's the frequency and size of configuration change?

- Median number of config lines changed per week
  - POP/DC devices: 500 lines
  - Ba
- Avg
  - POP/DC devices: 2.53
  - Backbone devices: 12.46

- POP/DC: few bigger config changes
- Backbone: many smaller config changes

Evolution of Robotron

Bottom-up, experience driven



Experience: Modeling is laborious

Problem Scenario: new eBGP session configuration

- A new eBGP session needed a proper import policy
- Robot[illegible] s link saturat[illegible]
- Most [illegible]

- Lesson: Modeling is hard
- Open problem: Lack of a network model widely accepted by vendors

Experience: Coupling changes is key

Problem Scenario: POP cluster switch turnup

1. An e
   gene
2. The
3. The

rgot to

- Lesson: Network design, config generation and deployment should be tightly coupled
- Open problem:
  - Atomicity
  - Conflict resolution

Experience: Fallback is important

Problem Scenario: Robotron-less management

- Engin
  - SSH
  - Ma
  - Log
- Neede
- Passively curtail with config monitoring

vices

- Lesson: Bypassing mechanism is needed
- Open problem:
  - How to reliably account for such activities?
  - How to safely revert such activities?

Conclusion

- First work sharing experience on a production network management system
- Open research problems:
  - Network modeling
  - Atomicity and conflict resolution across management tasks
  - Make network management system work with manual fallback mechanisms

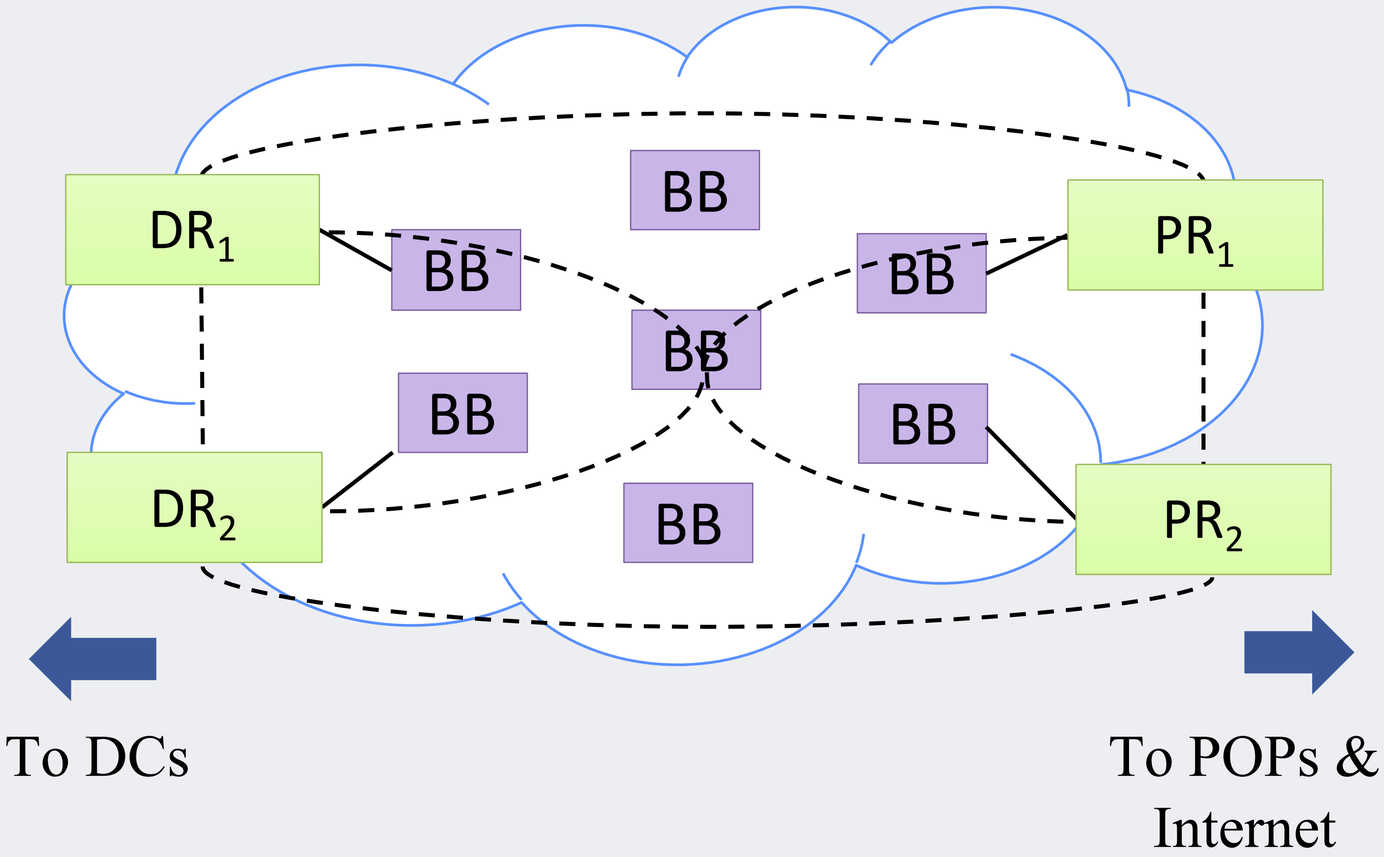
Questions?

- robotron@fb.com
- Poster session on Thursday

Overview of Facebook's Network

Backbone: Interconnecting POPs/DCs

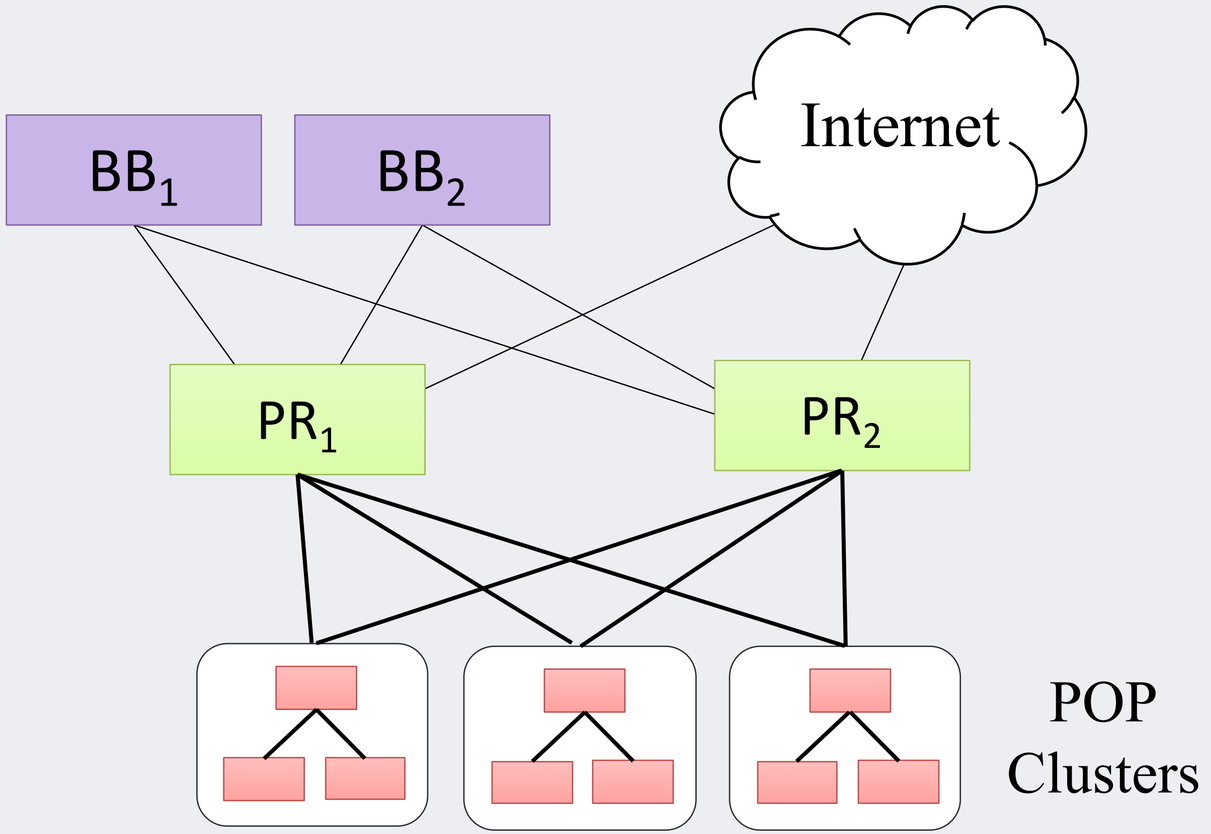
- Irregular, demand-driven topology
- PRs/DRs form an iBGP mesh
- Common tasks:
  - Add/migrate circuits
  - Add/remove BBs/PRs/DRs



Overview of Facebook's Network

Point of Presence (POP)

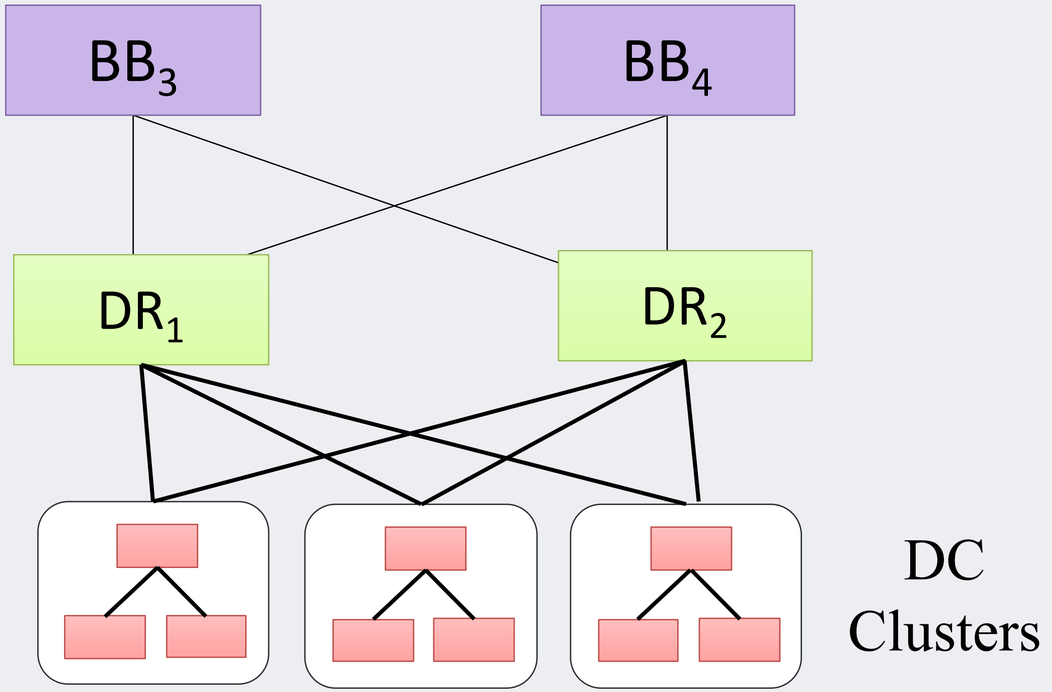
- Standardized topology
- Services: LB (Proxygen), Cache
- Common tasks
  - Build/upgrade a cluster
  - Provisioning new peering circuits



Overview of Facebook's Network

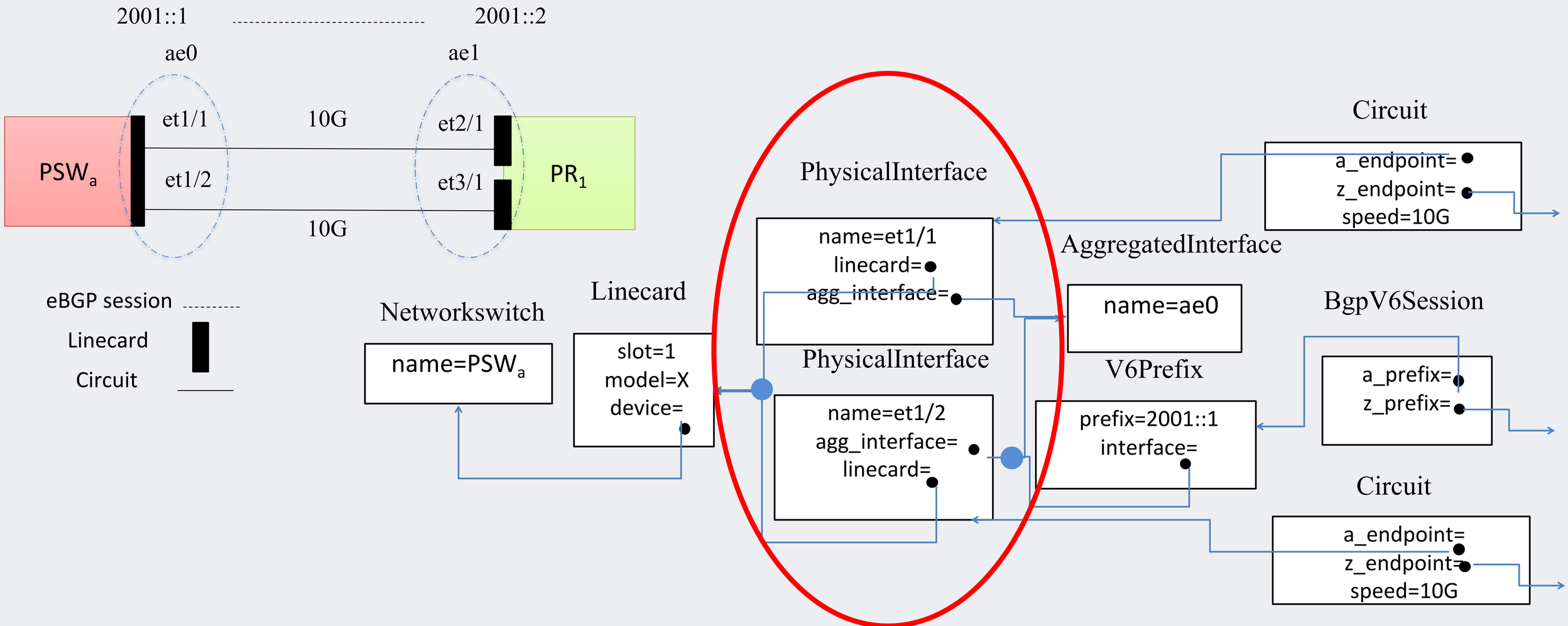
Data Center

- Standardized topology
- Services: Web, Cache (TAO), Database
- Common tasks
  - Build/decomm a cluster
  - Cluster capacity upgrade

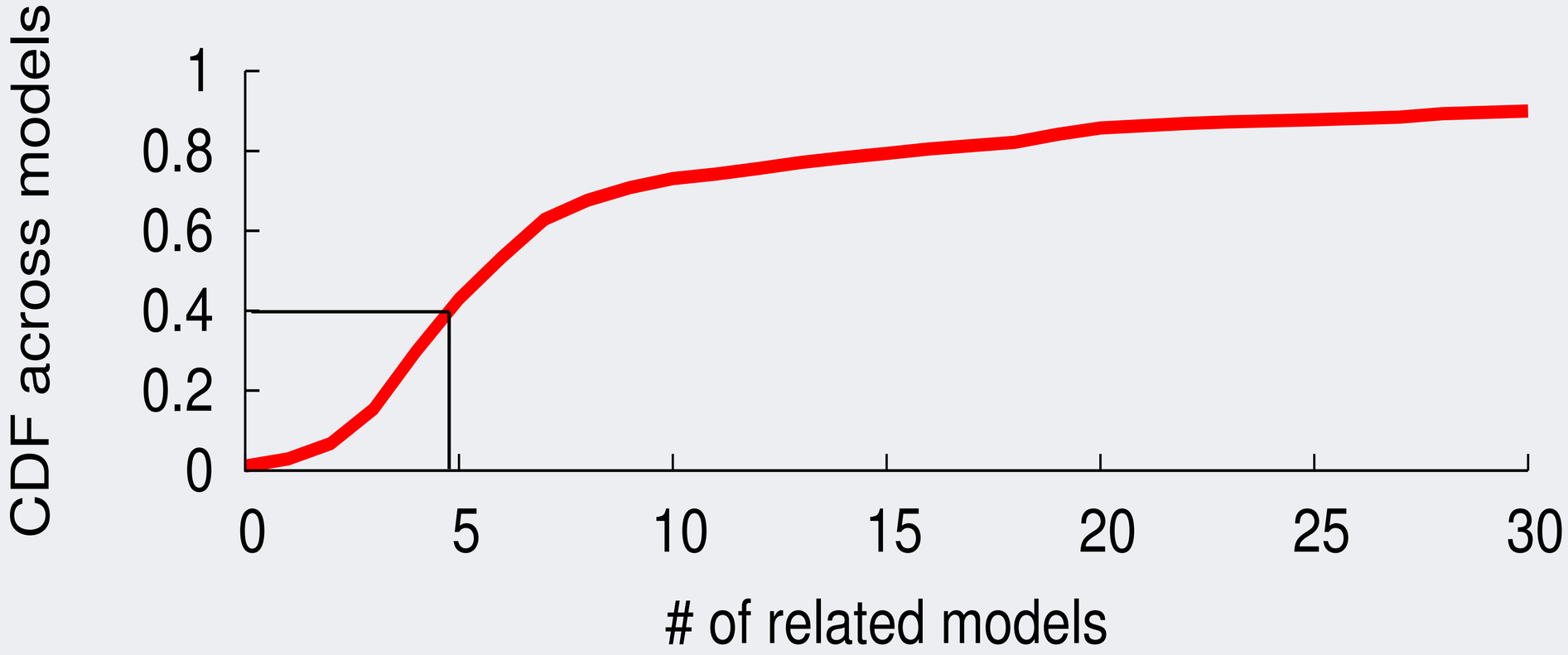


FBNet: Modeling the Network

Object, Value, and Relationship



Dependencies between FBNet models



Experience: Fallback is needed

Problem Scenario: manual changes to devices

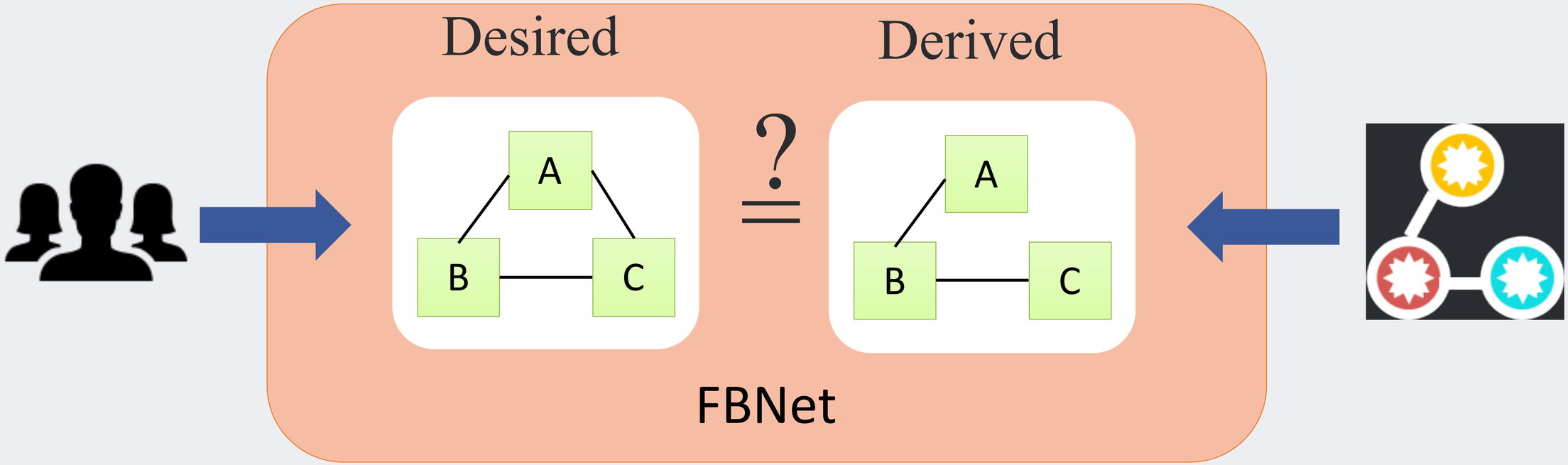
- Manual config changes on devices are error-prone
- Ideal: All changes made through Robotron
- Reality: Robotron has latency, bugs and missing features. Quick fixes needed upon emergency
- Alternatives to discourage manual changes:
  - Config monitoring
  - Automatic config override after emergency window

Related Work

- Bottom-up config analysis:
  [Benson11,Sung09,Kim11,…]
- Abstraction-driven design and config generation:
  - Top down config optimization: [Condor, Sun13]
  - Centralized platform for network management: [Onix, Statesman]
  - Template based config generation: [Enck09]
  - Config modeling: [OpenConfig, DMTF]

FBNet: Modeling the Network

Desired versus Derived



Deployment

Device configs → Devices

- New device: full config replacement
- Existing devices: Incremental “Live” updates
  - Dryrun, Atomic, Phased, etc

Monitoring

Is the network healthy?

- Passive monitoring
- Active monitoring
- Config monitoring

facebook