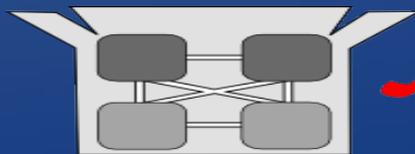


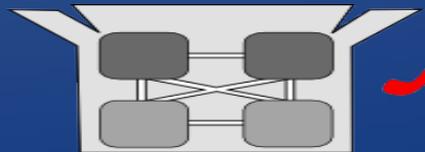
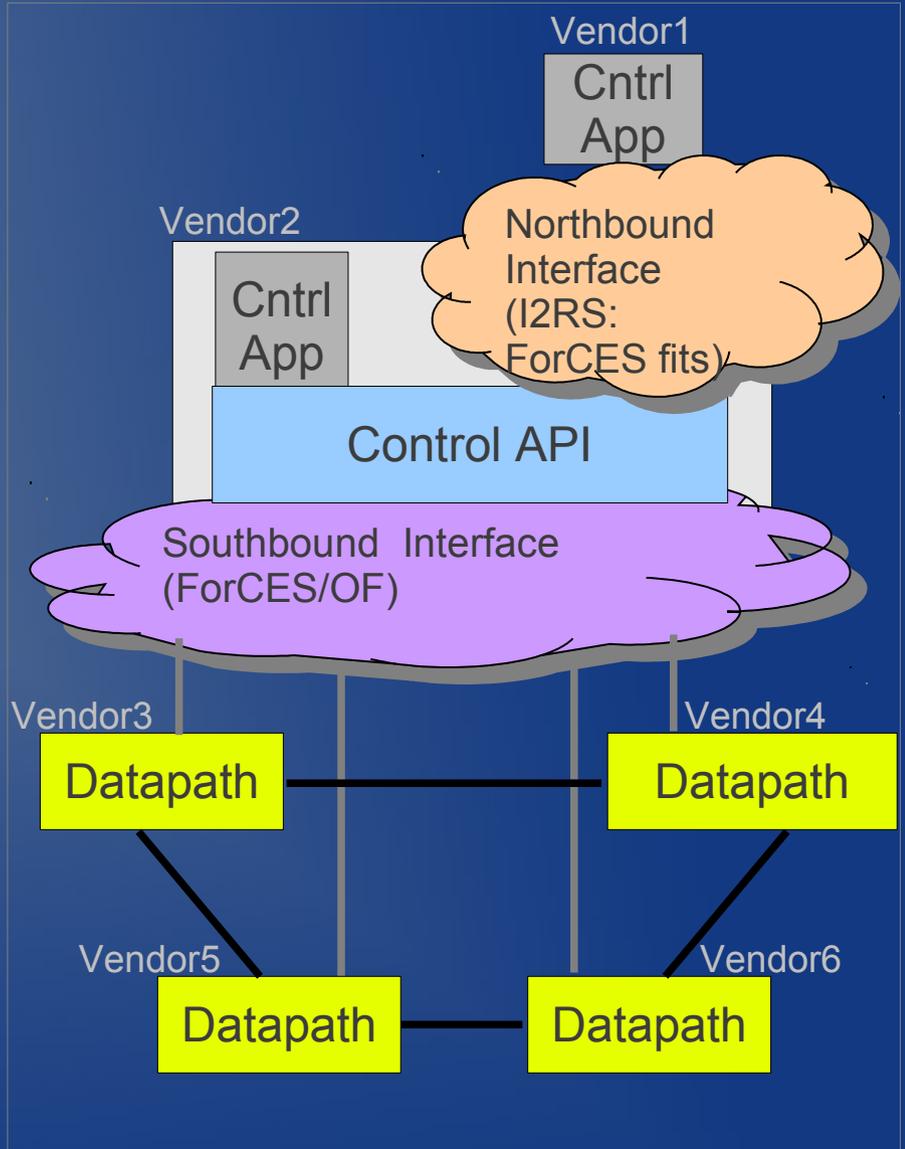
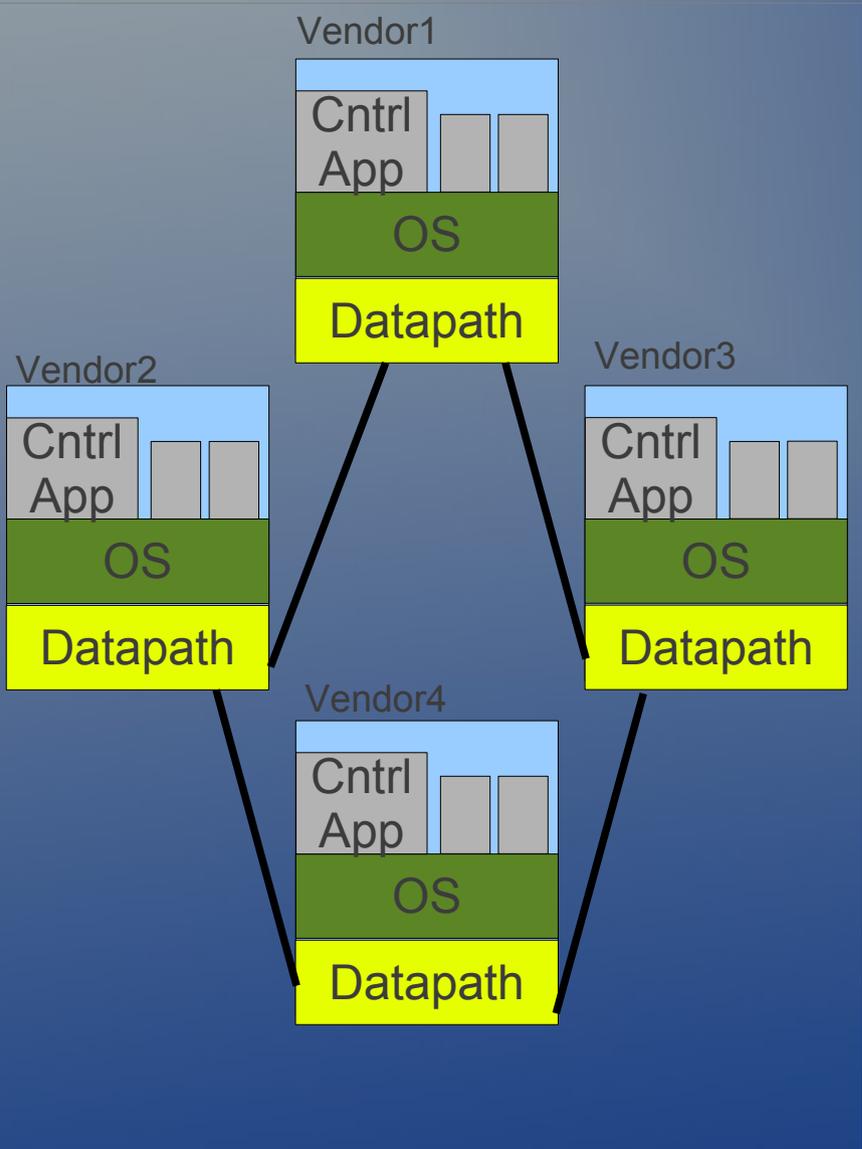
# A Treatise On ForCES



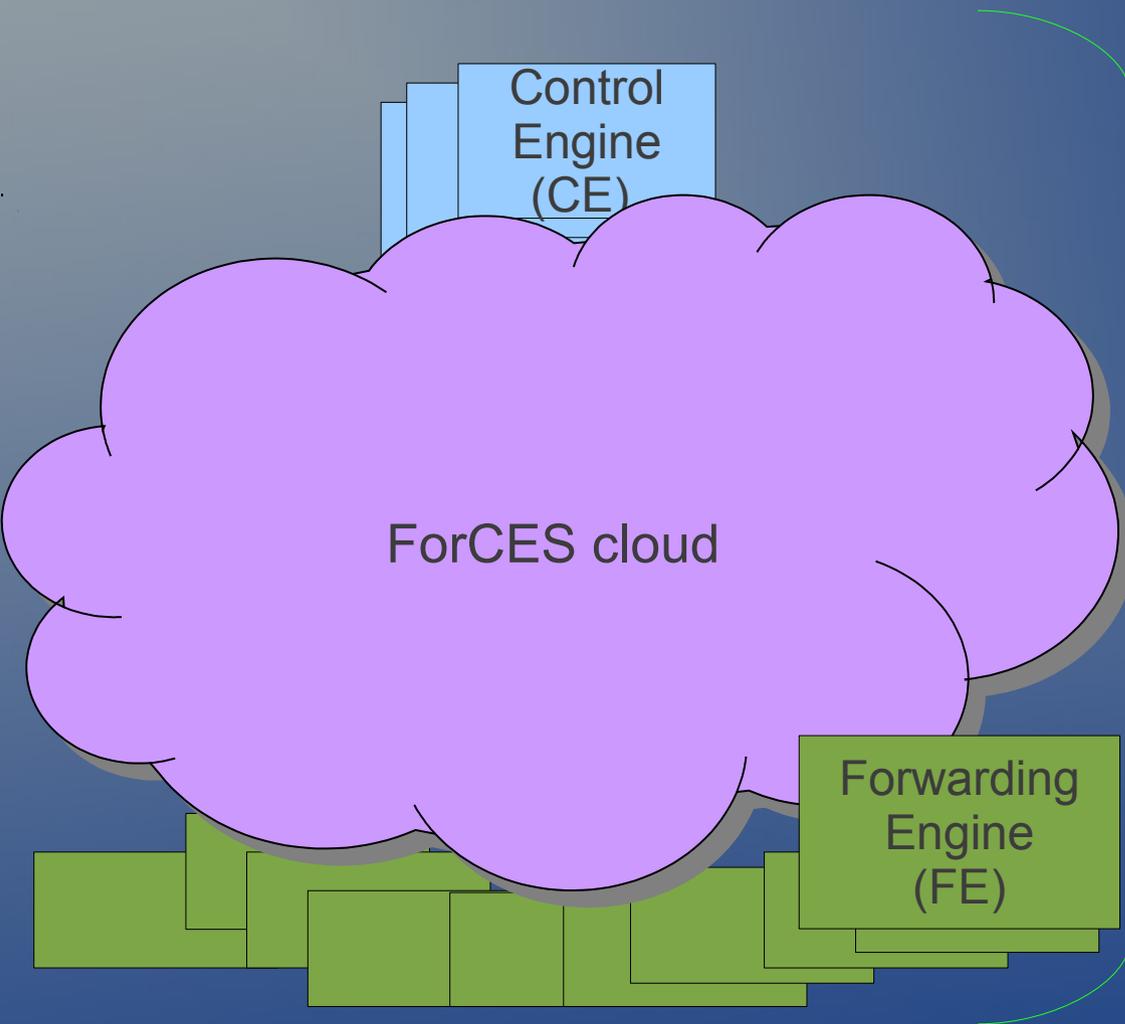
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# SDN

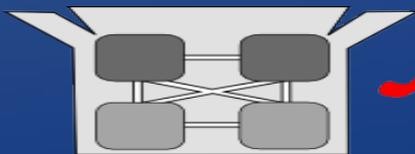


# ForCES: Functional scope

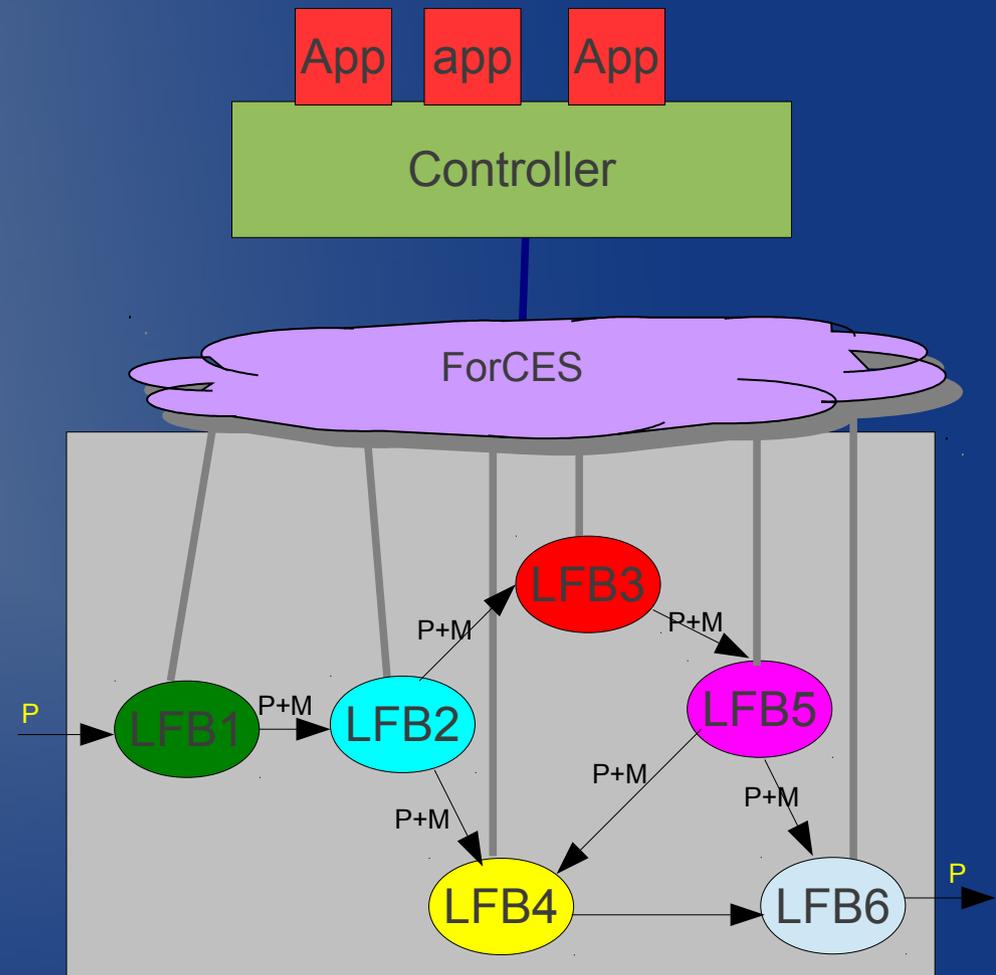
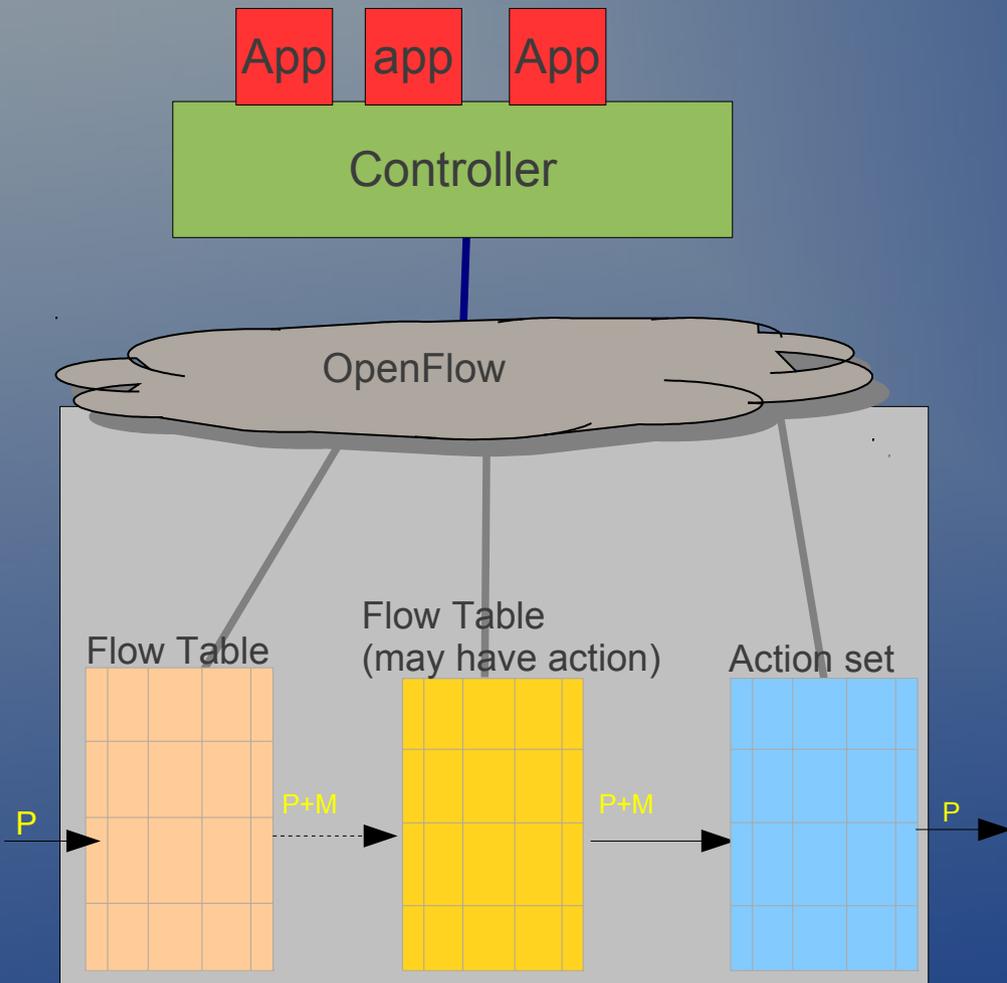


- Network Element (NE)
  - Packet Processing Entity
    - Constitutes CEs and FEs
    - Multiple CEs to FE for HA
    - CE/FE Physical or virtual

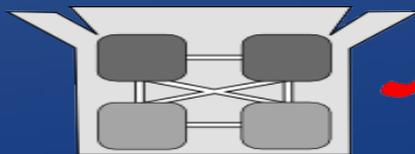
- NE components distributed
  - Local within box/rack/room
  - Geographically distributed
    - Within rooms/buildings
    - Across the internet



# Southbound Approaches

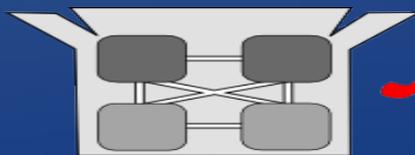


\*LFB = Logical Functional Block



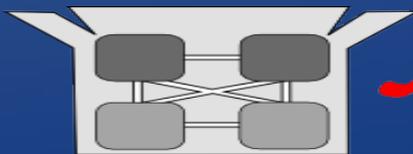
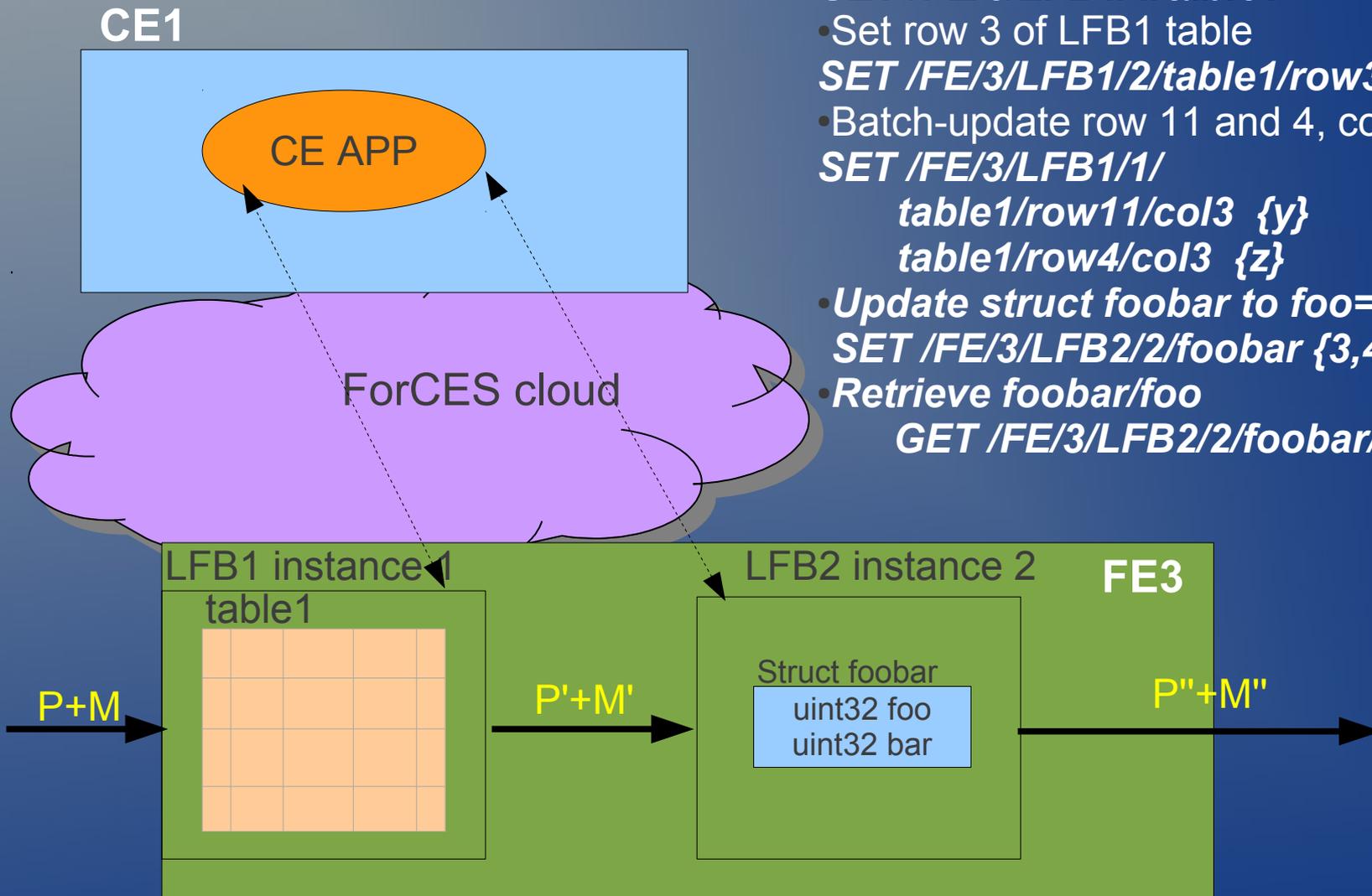
# Architecture In A Nutshell

- A protocol (The *Verbs*)
  - A modular transport for the protocol
- A data model (The *nouns*)
  - Logical Functional Block constructs
- Combine the above and you have a language
  - [*<verb> <noun> [args]*]<sup>+</sup>
    - Few verbs but infinite possibilities of nouns

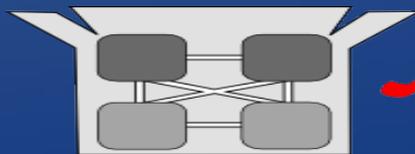
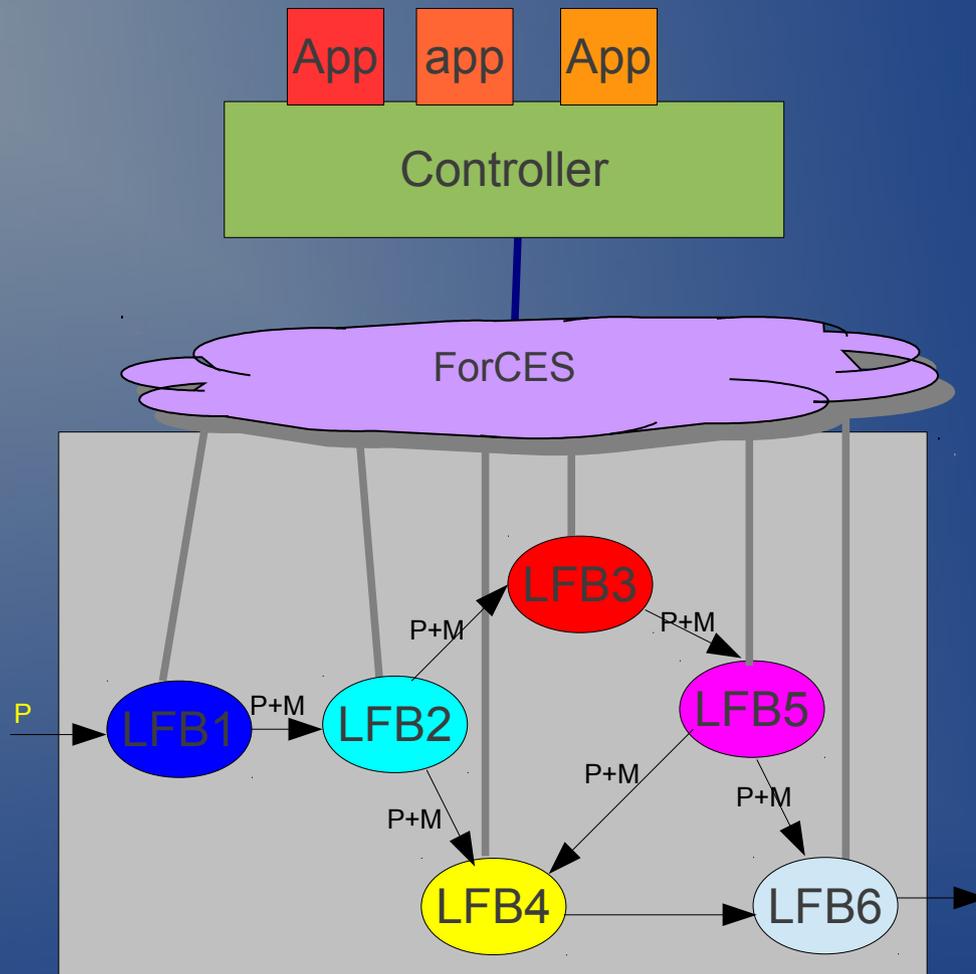


# General Control Example

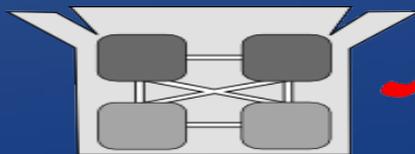
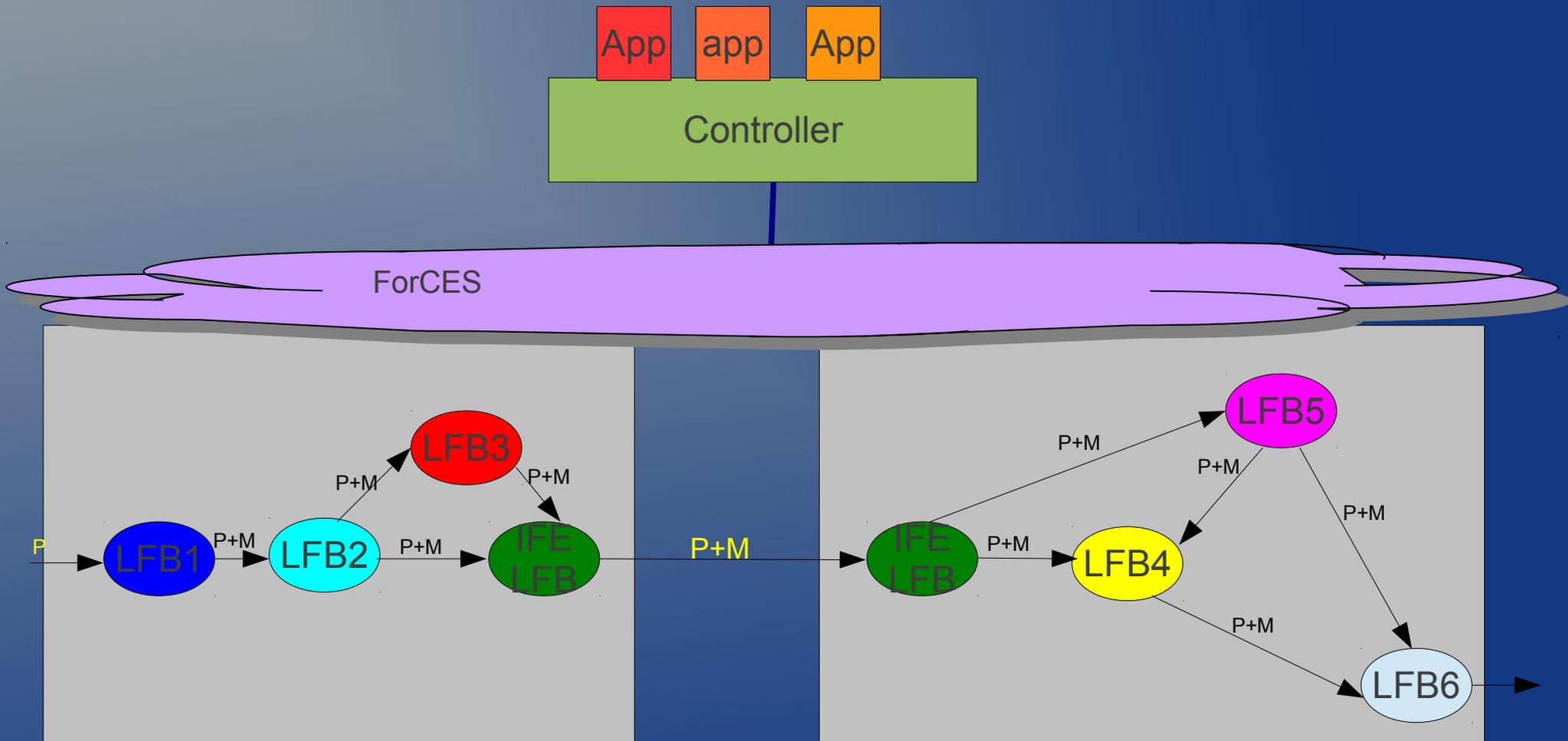
- Dump the LFB1 table  
**GET /FE/3/LFB1/1/table1**
- Set row 3 of LFB1 table  
**SET /FE/3/LFB1/2/table1/row3 {a,b,c,d}**
- Batch-update row 11 and 4, col 3 of the LFB1 table  
**SET /FE/3/LFB1/1/  
table1/row11/col3 {y}  
table1/row4/col3 {z}**
- Update struct foobar to foo=3, bar=4  
**SET /FE/3/LFB2/2/foobar {3,4}**
- Retrieve foobar/foo  
**GET /FE/3/LFB2/2/foobar/foo**



# LFB Topology Service Chain

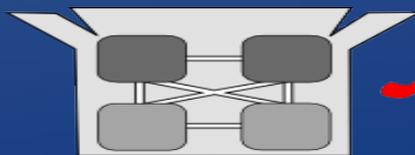


# Distributed Service Chain (new Recharter Work)



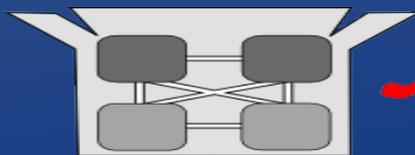
# Protocol Framework

- A Protocol Layer
  - Base ForCES semantics and encapsulation
  - Standardized in RFC 5810
- A Transport Module Layer
  - Depends on underlying media or transport
  - One is standardized (RFC 5811)
    - Expect others to be defined in the future

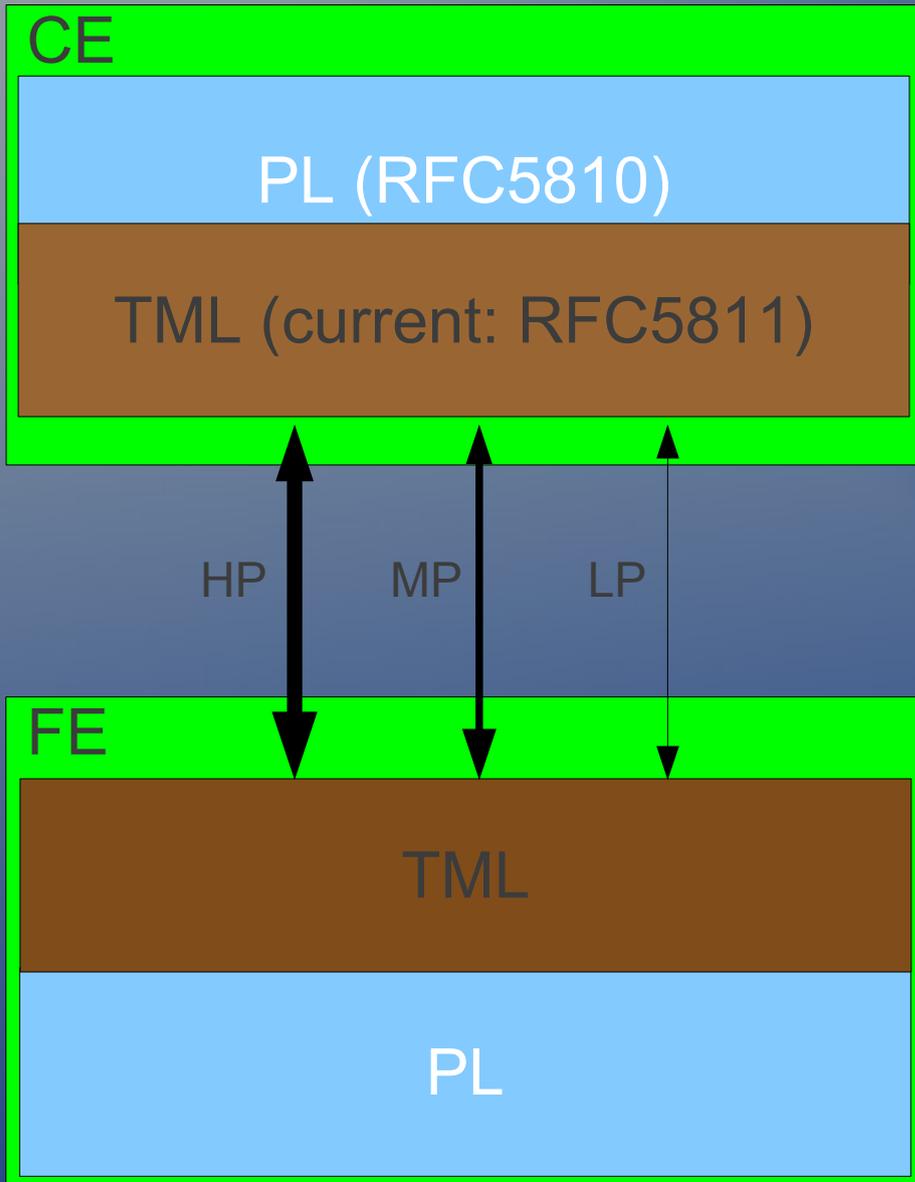


# Protocol Semantics

- Simple Verbs
- Transactional capability (2PC)
- Various Execution modes
- Scalability via batching and command pipeline
- Security
- Traffic Sensitive Heartbeating
- High Availability

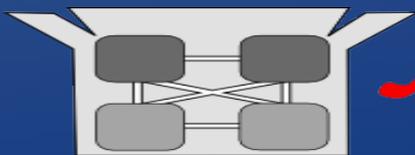


# SCTP TML



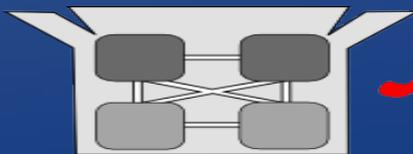
- **Strict Priority Scheduling**

- HP: Strictly reliable channel
  - Configs and Queries issued by CE
  - Response by the FE
- MP: Semi-reliable
  - Event notifications from FE
- LP: Unreliable channel
  - Packet Redirects and HBs



# Data Modeling

- Based on XML (RFC 5812)
- Respect for backward and forward compat
  - Let the CE deal with disparate versions
- Main constructs
  - *Datatype*: definitions used by LFBs
  - *LFB Classes*: Basic packet processing entity
    - *Components*: Control entities a CE is aware of
    - *Capabilities*: define LFB capabilities
    - *Events*: define events that an LFB can generate



# LFB model

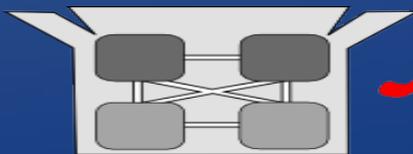
Datatype definition

LFB Definition

Components

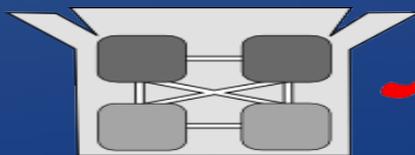
Capabilities

Events



# Data Modeling

- Data types: *atomic* and *compound*
- Components have properties
  - ACL (Read/Write permissions)
  - Arrays, Strings, octetstrings, events
    - Events can be subscribed/unsubscribed
- Tables/arrays are accessed by index or by key
- Aliases (symlinks) and optional components
- Read RFC 5812 for more details



# LFB model Example

Datatype definition

```
<dataTypeDef>
  <name>foobartype</name>
  <synopsis>Describes The foobar</synopsis>
  <struct>
    <component componentID="1">
      <name>foo</name>
      <synopsis>that foo</synopsis>
      <typeRef>uint32</typeRef>
    </component>
    <component componentID="2">
      <name>bar</name>
      <synopsis>the bar</synopsis>
      <typeRef>uint32</typeRef>
    </component>
  </struct>
</dataTypeDef>
```

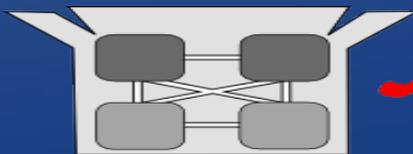
MyLFB

Components

Capabilities

Events

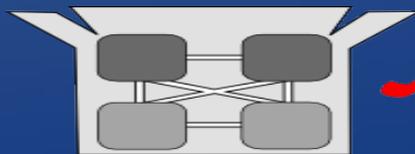
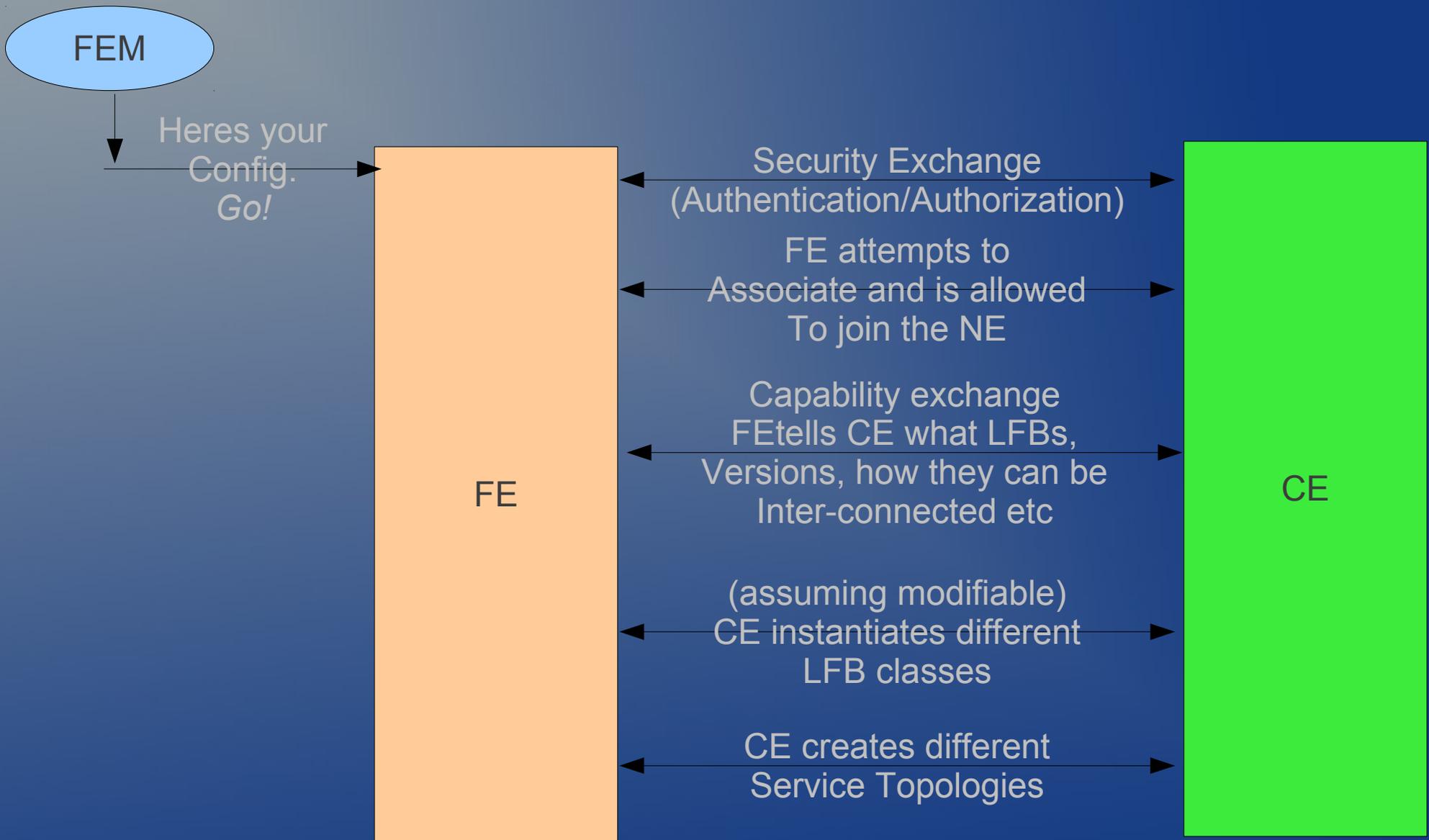
```
<component componentID="1" access="read-write">
  <name>foobar</name>
  <synopsis>The Foo and Bar thingy</synopsis>
  <typeRef>foobartype</typeRef>
</component>
```



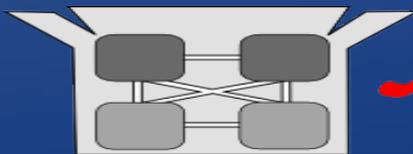
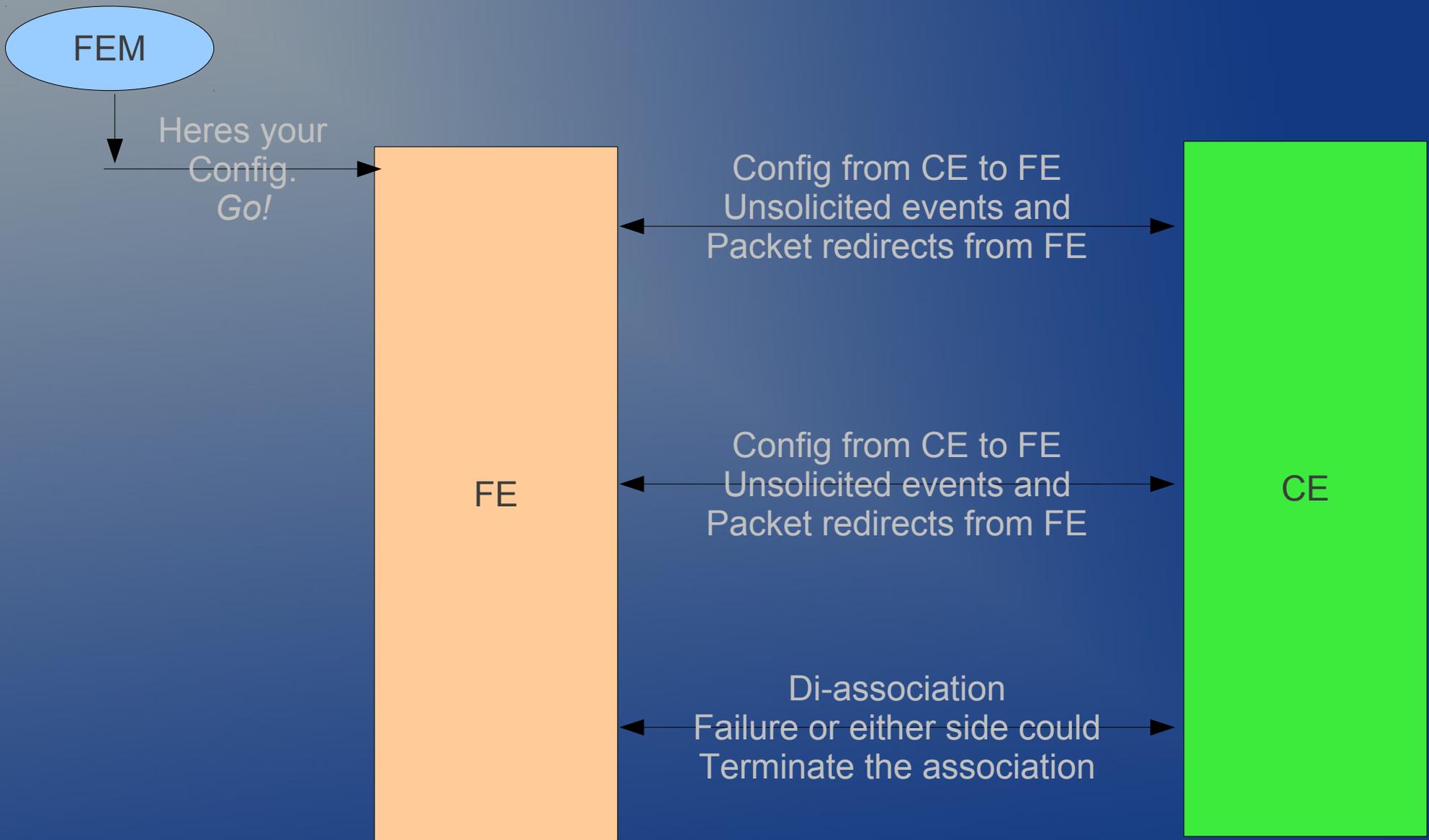
# Development of LFB/Apps

- University of Patras DSL toolkit
- Sample LFB and CE/North App

# One day In The Life OF An FE

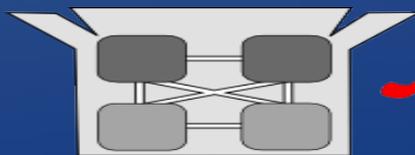


# One day In The Life OF An FE



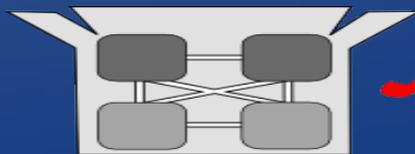
# Have Model, Will travel

- Initial ForCES intent: southbound datapath control
- Experience: Semantics are good enough for
  - Northbound interface
  - Managing config
  - General purpose encoding and transport of data
    - Not unlike protobuf or thrift



# Current Status

- Architecture pretty mature
  - Several implementations exist
  - Two interop meetings in the last 3-4 years
- WG just got rechartered

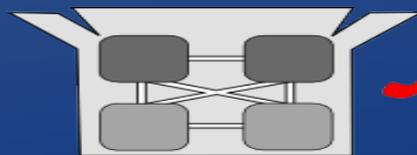


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# How To Get Involved

- Read the RFCs
  - <https://datatracker.ietf.org/wg/forces/>
- Join the Mailing list
  - <https://www.ietf.org/mailman/listinfo/forces>
- Help us spread the word
  - Tell the ONF about the existence of ForCES
- To contact me: [hadi@mojatatu.com](mailto:hadi@mojatatu.com)

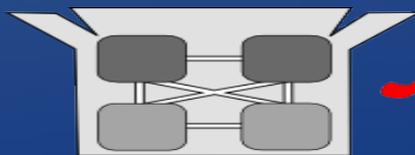


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# References

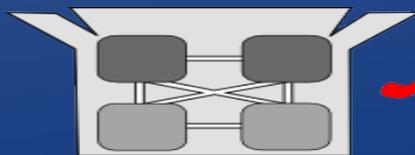
- All ForCES documents:
  - <https://datatracker.ietf.org/wg/forces/>
- A good high level paper
  - E. Haleplidis, S. Denazis, O. Koufopavlou, J. H. Salim, and J. Halpern, “Software-Defined Networking: Experimenting with the control to forwarding plane interface,” in Software Defined Networking (EWSDN), 2012 European Workshop on, 2012, pp. 91–96.
- DSL Paper:
  - E. Haleplidis, C. Tranoris, S. Denazis, and O. Koufopavlou, “Adopting software engineering practices to network processor devices introducing the Domain Specific Modeling paradigm to the ForCES Framework,” in Network and Service Management (CNSM), 2010 International Conference on, 2010, pp. 366–369.



# References

- Implementations

- Weiming Wang, Ligang Dong, B Zhuge, "ForTER-An Open Programmable Router Based on Forwarding and Control Element Separation", DCABES 2006 (Distributed Computing and Applications to Business, Engineering and Science), Volume [C]. Oct 2006
- Kyota Hattori, Hiroki Date, Kentaro Ogawa, Takahiro Kobayashi, Kenichi Higuchi, Hideaki Iwata, Michihiro Aoki, Shinichiro Chaki. "FDTN Architecture: Functionally Distributed Transport Networking Architecture", SIGCOMM 2009, Demos 1 8, Aug 2009
- Haleplidis, E., Haas, R., Denazis, S., Koufopavlou, O., "A Web Service-and ForCES-based Programmable Router Architecture". IWAN2005, France.
- Mojatatu Networks (commercial support)



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