Cisco Connect

Praha, Hotel Clarion
10. – 11. dubna 2013

Network Programming
in a
Cisco Open Network Environment

Start using onePK and EEM

T-SDN4/L3

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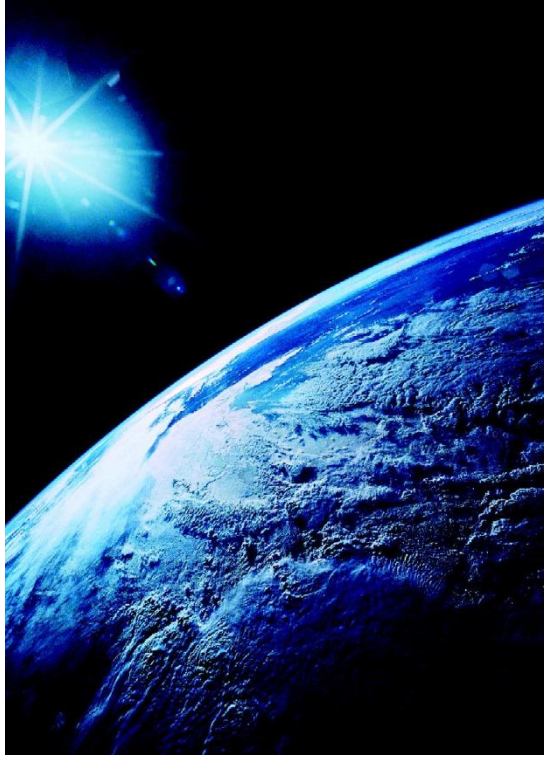

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An Analogy

Highly motivated individuals

Full control over every single detail

Highly skilled and trained crew

Human brain in every control loop

Specialized distributed crew

Reasonable control within boundaries

From: Detailed control by a single central authority

Towards: Collaborative operations of a partially autonomic system

Software – Network Convergence

"Computer programming is an art,

because it applies accumulated knowledge to the world,

because it requires skill and ingenuity,

and especially because it produces objects of beauty"

Donald Knuth, 1974

(Author of "The Art of Computer Programming")

Cisco Open Network Environment

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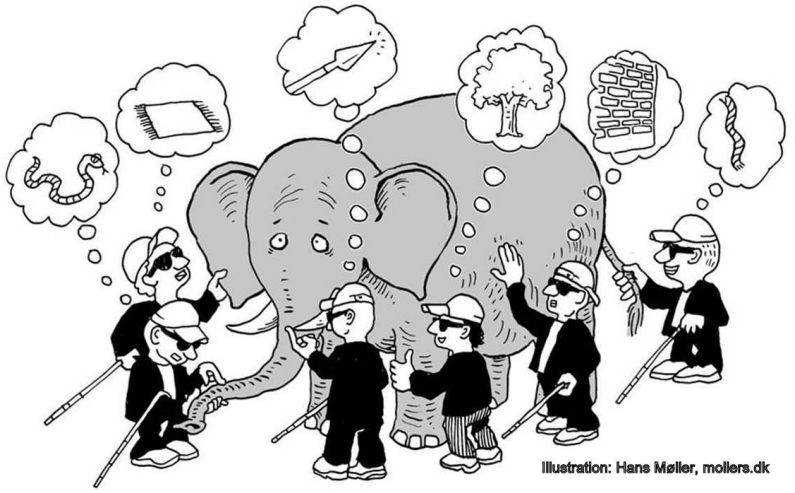
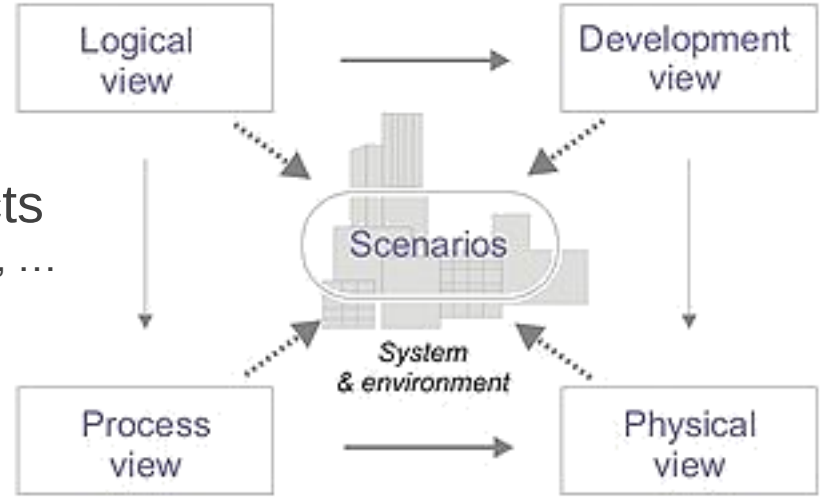
Describing Software Architectures



4+1 View Model

Scenarios:	Use Case, Who, What and Why
Examples:	Routing-for-(Dollars), Application-Flow-Manipulation, Network Slicing, SDDC Provisioning, CIN, …
Development View:	SDKs, Packages, Libraries, Tools
Examples:	onePK SDK, binaries, .so, Eclipse, Debugger, IOL, …
Logical View:	Features, Functions, Classes, Abstractions
Examples:	onePK APIs in C, Java, Application APIs, …
Process View:	Architectures, Processes, Interactions, Objects
Examples:	Agents, Controllers, Thrift IDL, Cloud Connectors, Sentinels, …
Physical View:	Deployment, Hosting, Topology, Connectivity
Examples:	Virtual Containers, Blades, Endpoints, L1-2-3, Overlay



See: https://en.wikipedia.org/wiki/4+1_Architectural_View_Model

Cisco Open Network Environment – ONE

Preserve What is Working

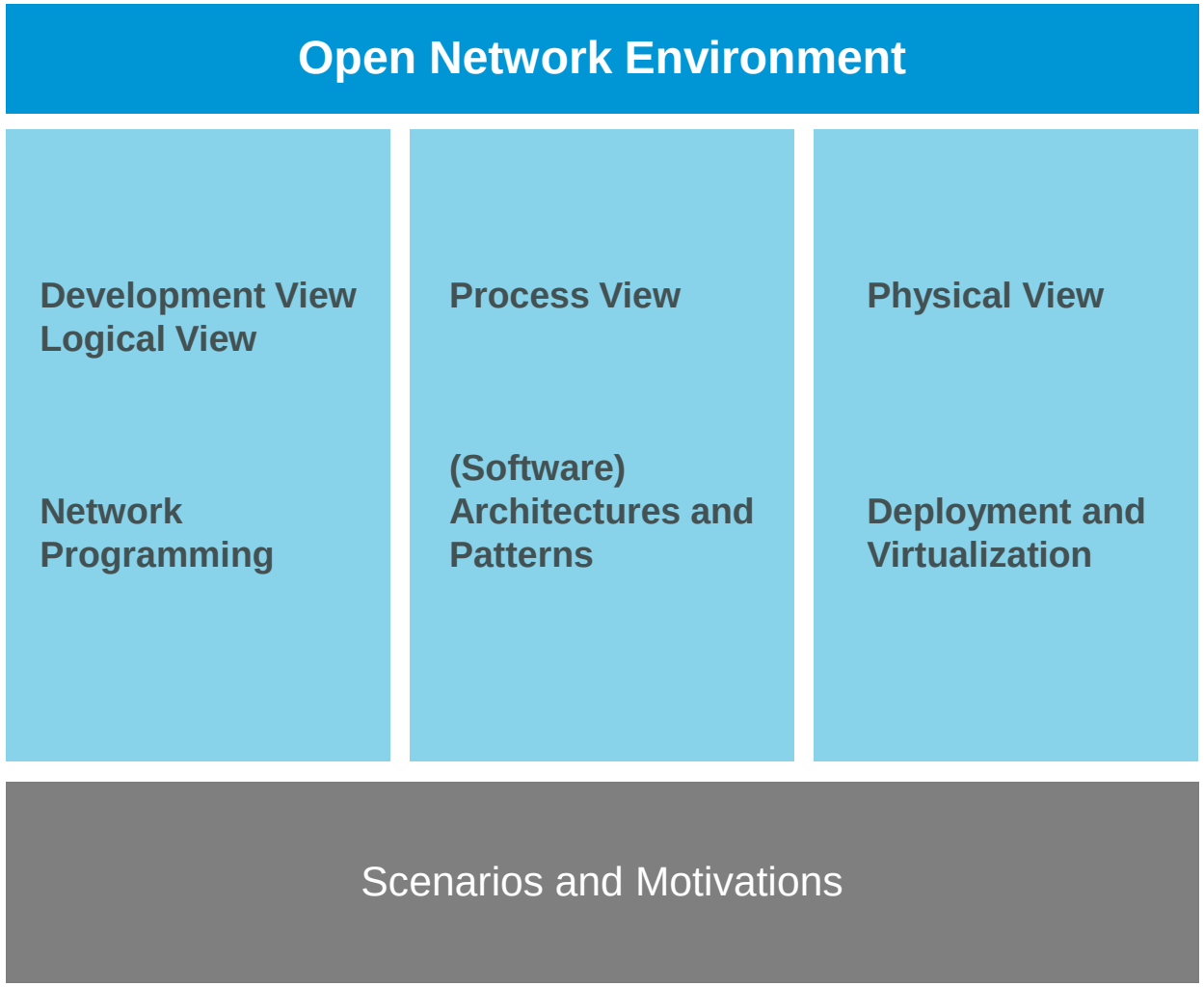
- Resilience, Scale, Security
- Functionality and Rich Features
- Instrumentation

Evolve for New Requirements

- Operational Simplicity and Automations
- Programmability and Network-Awareness
- Upcoming Innovations

Open and Integrated Framework

- Software Defined Network concepts are a component of the Open Network Environment
- Existing APIs, Agents, Controllers and Infrastructure contribute



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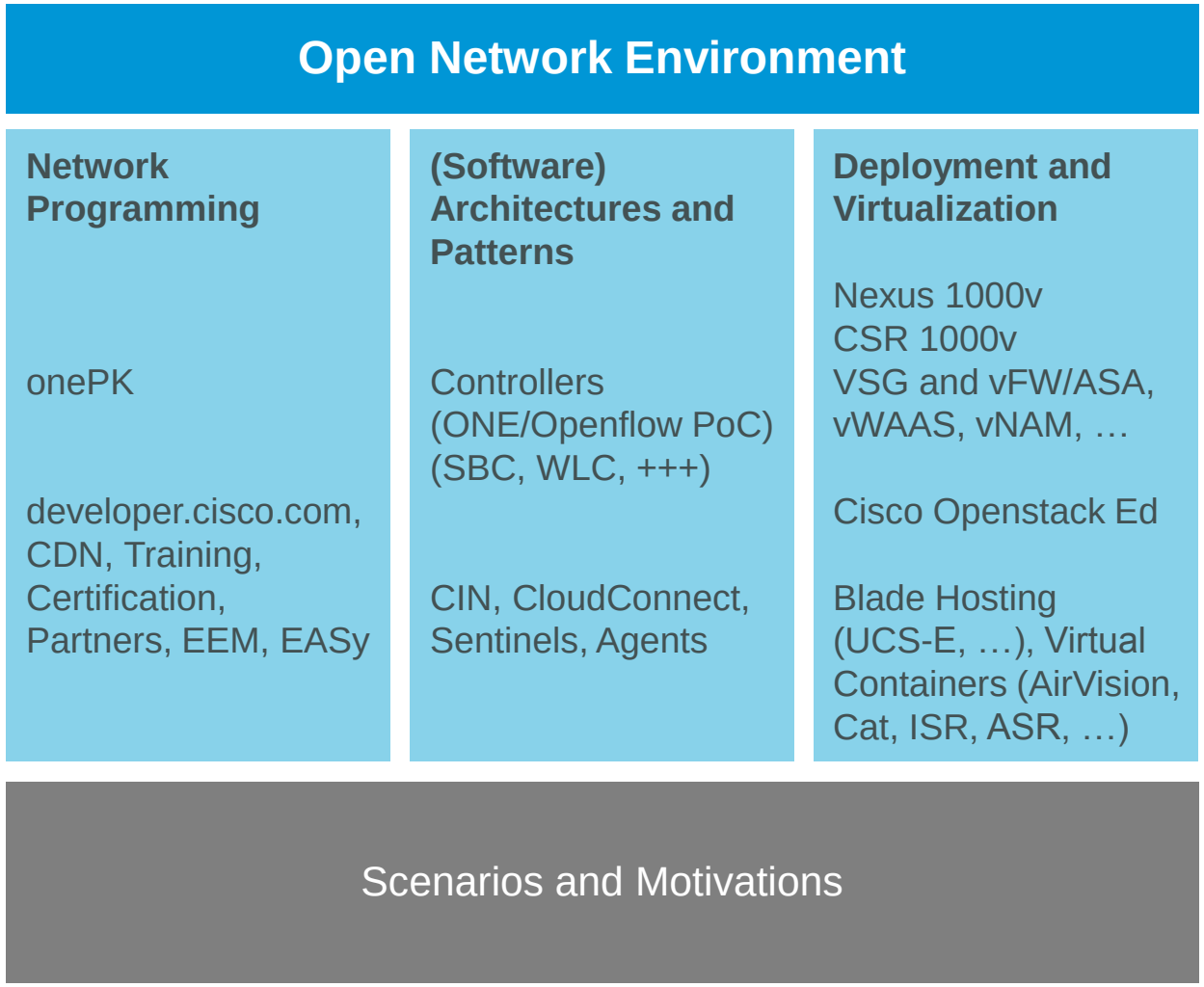

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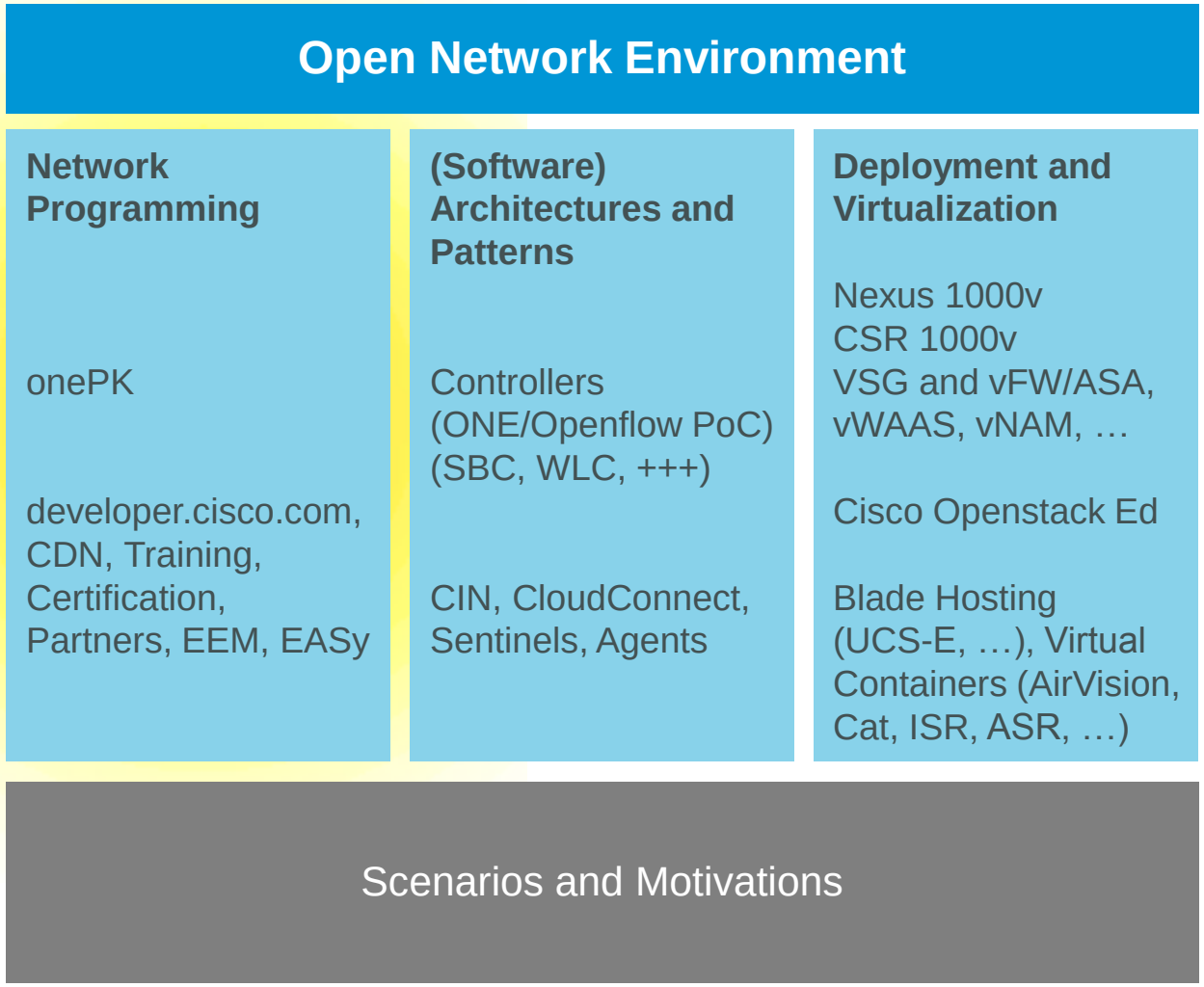


Network Automation and Manageability

Cisco IOS® Device Manageability Instrumentation (DMI)

Fault

- **IP OAM**—Ping, Trace, BFD, ISG per session
- **802.3ah**—Link monitoring and remote fault indication
- **802.1 ag**—Continuity check, L2 ping, trace, AIS
- **MPLS OAM**—LSP ping, LSP trace, VCCV
- **EEM**—Embedded Event Manager
- **EVENT-MIB**—OID-based triggers, events, or SNMP Set, IETF DISMON
- **EXPRESSION-MIB**—OID expression-based triggers, IETF DISMON
- …

Configuration

- **Config CLI**—diff, logging, lock, replace, rollback
- **E-LMI**—parameter and status signaling
- **E-DI**—Enhanced Device Interface, CLI, Perl, IETF Netconf
- **EMM —** Embedded Menu Manager
- **NETCONF—**IETF NETCONF XML PI
- **CNS** and **WSMA**
- **TR-069**
- **KRON**—command scheduler
- **AutoInstall**—bootstrapping
- **IOS.sh** —IOS Shell
- **SmartInstall**
- **Auto SmartPorts**

Performance

- **Auto IP SLA**—delay, jitter, loss probability
- **CBQoS MIB**—class-based QoS
- **NBAR**
- **RMON**
- **EPC** – Embedded Packet Capture
- **ERM**—Embedded Resource Manager
- **GOLD**—Generic Online Diagnosis
- **Smart Call Home**—preventive maintenance
- **VidMon**—Video Monitoring
- …

Accounting

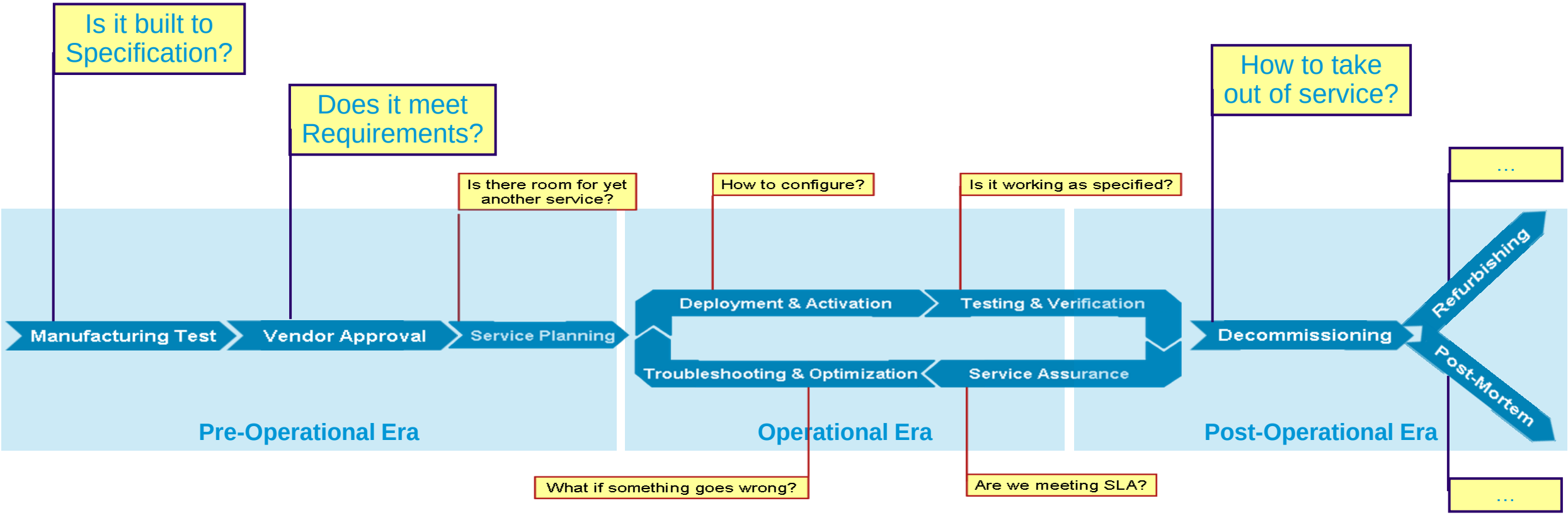
- **Flexible NetFlow**—IETF IPFIX
- **BGP policy accounting** – includes AS information
- **Periodic MIB bulk data collection and transfer**
- …

Security

- **Auto Secure**—one-touch device hardening
- **LDP Auth**—message authentication
- **Routing Auth**—MD5 authentication, BGP, OSPF
- …

Device Manageability Instrumentation Has Evolved Significantly

Network Automation Life-Cycle Span



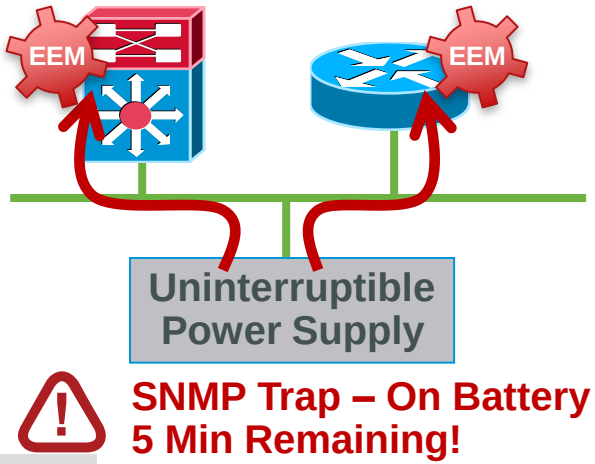
Network Automation spans across full Life Cycle

Trigger a Workflow in the Network

Problem: Sometimes we want to receive remote information on a Router / Switch and be able to react to it locally – for example a notification from a UPS System.

Solution: Use Network Automation based on Cisco IOS Embedded Event Manager leveraging the EEM SNMP Notification Event Detector

- Router / Switch can received SNMP Notifications
- Execute (trigger) EEM Policy to take local action
- Policy can query varbind info
- Supports Incoming or Outgoing Notifications
- Outgoing only for locally generated Notifications

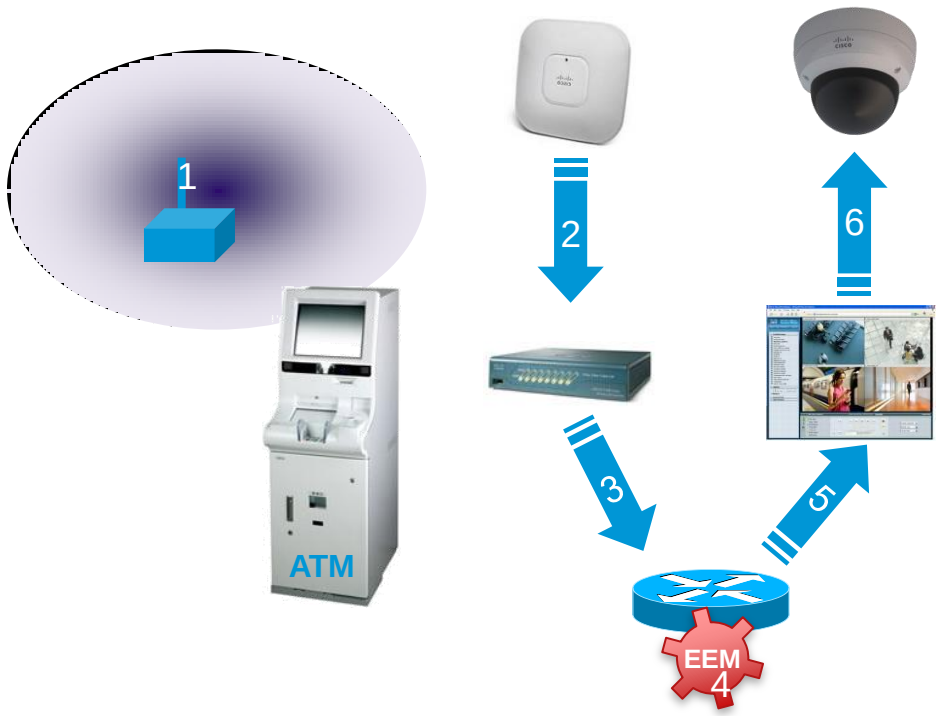



```
Router(config}# event manager applet catch-a-trap
router(config-applet)# description test snmp notification unmanaged service
router(config-applet)# event snmp-notification oid 1.3.6.1.6.3.1.1.4.1.0
        oid-val "1.3.6.1.6.3.1.1.5.3" op eq src-ip-address 10.51.89.176
        direction incoming
router(config-applet)# action 010 …
router(config-applet)# action 020 …
```

Trigger a Workflow from the Network

Problem: A new rogue WLAN device in sensitive areas should be detected by Cisco CleanAir and automatically focus/pan/zoom a security camera.

Solution: Use Network Automation based on Cisco IOS Embedded Event Manager to receive an SNMP Notification from WLC and trigger the Video Operations Manager via HTTP



1. Rogue WLAN Device added
2. Rogue Device detected by CleanAir AP
3. WLC sends SNMP Notification
4. EEM triggers upon SNMP Notification
5. EEM notifies VSOM via HTTP
6. Security Camera Focus/Pan/Zoom

Collect and Share Remote Information – 1/2

Problem: How to actively gather and share information from a router and from a few devices behind the router – across organizational and technical borders?

Solution 1: Initiate a project to make use of SNMP, Syslog, Event Management Software, Reporting, Provisioning and CRM Systems ...

Solution 2: Use Cisco IOS Network Automation to collect and post the information

Using Cisco IOS Embedded Event Manager and Tcl:

1. Import the http package into EEM policy

```
namespace import ::http::*
```

2. Collect the information required

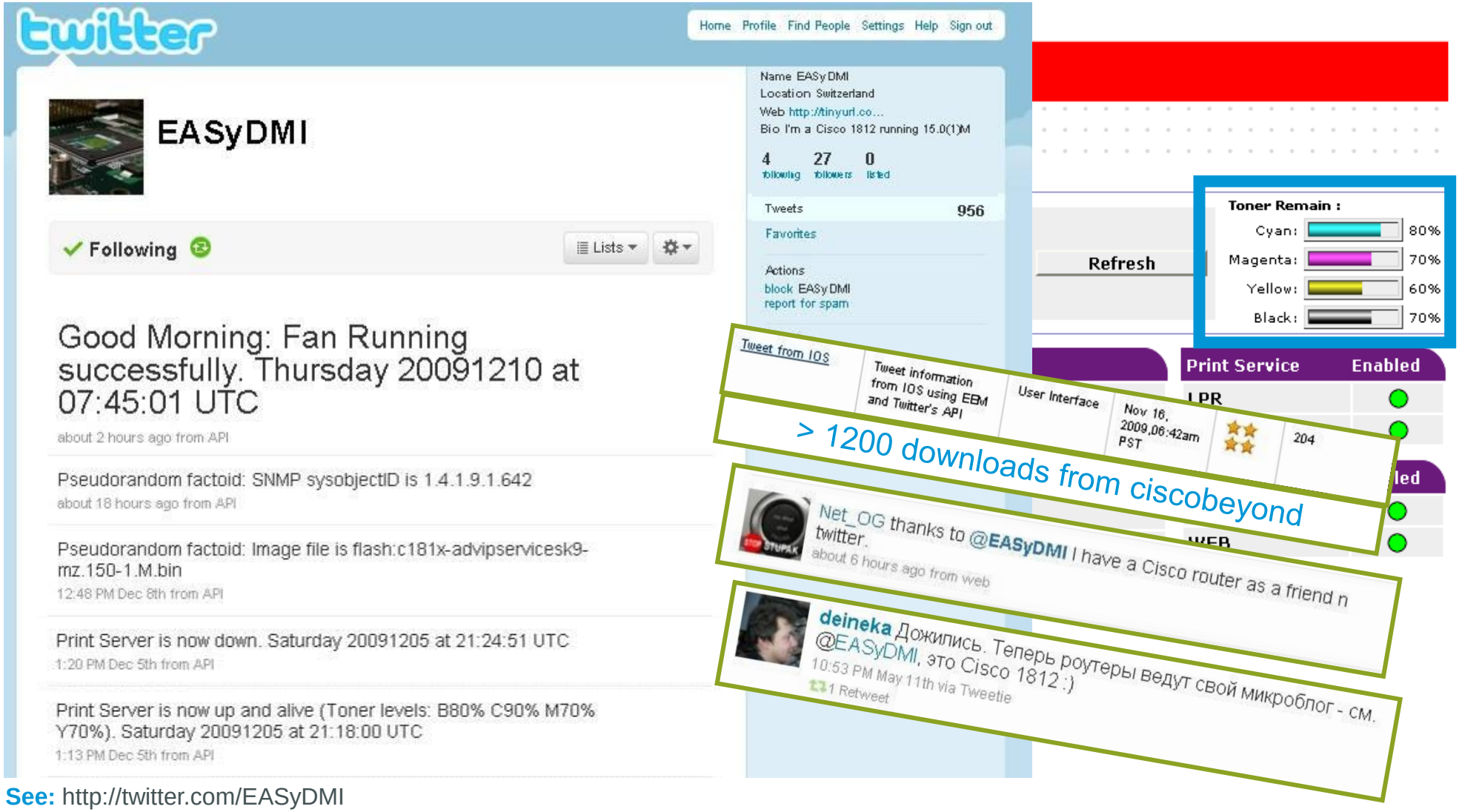
3. Build a query for the http POST operation

```
set my_query [::http::formatQuery "status" $my_info]
```

4. POST the information to a website

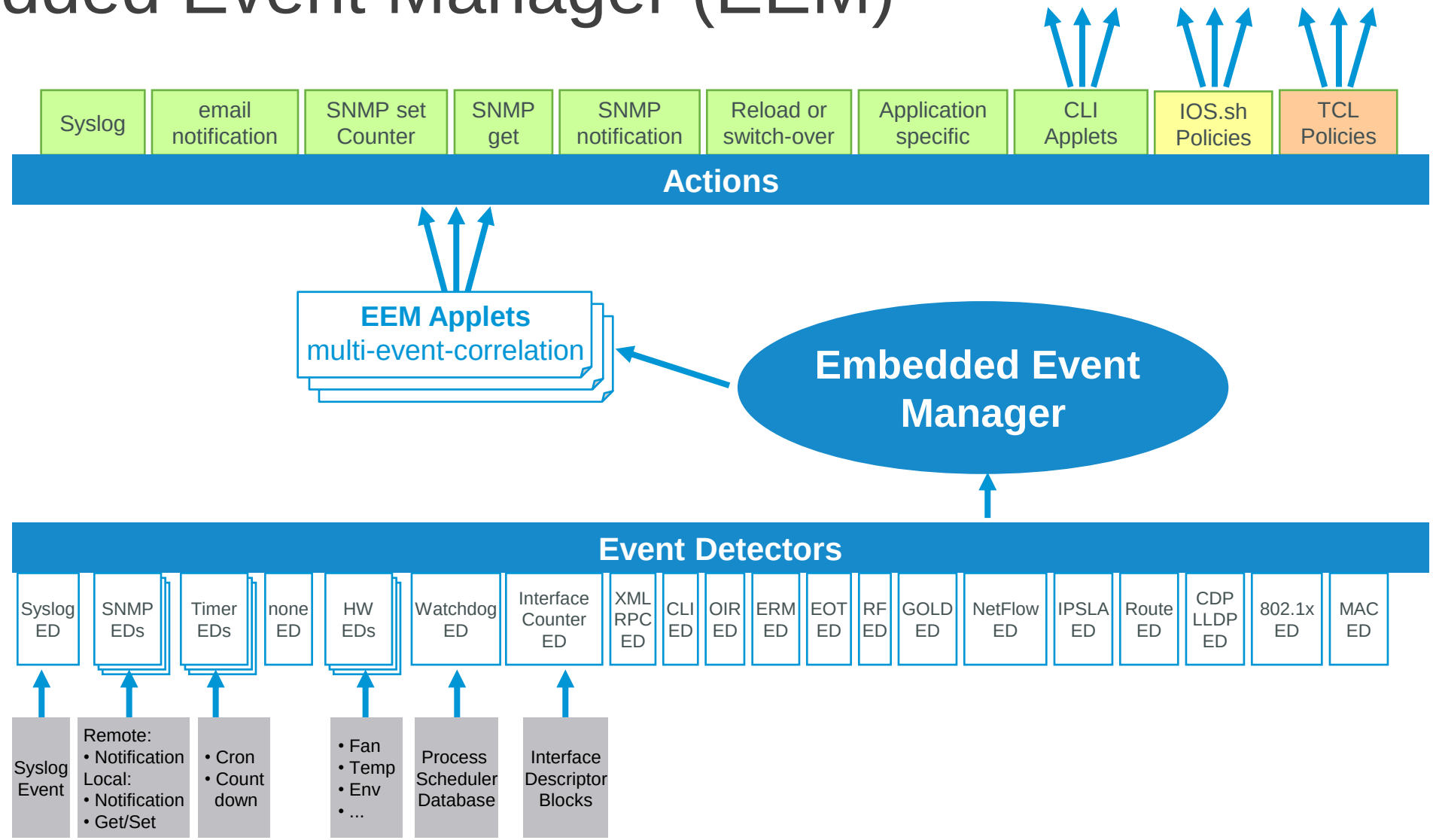
```
set my_reply [::http::geturl $my_server_url -query $my_query]
```

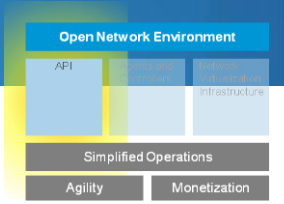
Collect and Share Remote Information – 2/2



See: http://twitter.com/EASyDMI
Note: it is NOT recommended to use a public site or feed other than for demo purpose

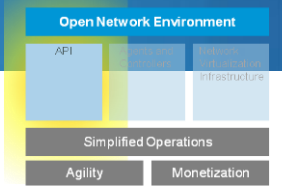
Embedded Event Manager (EEM)





Embedded Event Manager – Applet Evolutions

EEM Version	Release	Applet Modifications	Peanut Gallery Comments
1.0	12.0(26)S 12.3(4)T	2 Events: Syslog, SNMP Actions: Log, CNS event, Reload, Switchover	Initial Version Limited benefits
2.0 2.1 2.2	12.3(14)T1 12.2(18)SXF5 12.4M	No structure changes Various New event detectors New actions: cli, info, mail, policy, SNMP trap, Modify counters, Publish application events, Read/set tracked objects	Many new actions Popular CLI / mail Actions run linear
2.3	12.4(11)T	maxrun support pattern parameter for CLI actions	Maxrun support == security Can handle CLI prompts
2.4	12.4(20)T	multi-event support	Boolean correlation of events within applet.
3.0	12.4(22)T 12.2(33)SE	Redesign of action mechanism Program counter added Loops, conditionals, regexps, context save, error handling	Applets now rock! Programming language feel.
3.1/3.2	-	No changes	-
4.0	15.2(2)T	Applet file actions TLS/SSL support for SMTP actions Custom port for SMTP actions	File manipulation handy!



Example: EEM Applets – Loops, Variables

Problem: None in Particular

Solution: Have fun exploring EEM Applet capabilities

```
event manager applet 99-bob
    description written by bklauser inspired by http://www.99-bottles-of-beer.net
    event none
    action 100 set b 99
    action 110 while $b gt 1
    action 120  puts "$b bottles of beer on the wall, $b bottles of beer."
    action 130  decrement b
    action 140  puts "Take one down, pass it around, "
    action 150  puts "$b bottles of beer on the wall.\n"
    action 160 end
    action 170 puts "$b bottle of beer on the wall, $b bottle of beer."
    action 180 puts "Take one down, pass it around, "
    action 190 puts "no more bottles of beer on the wall.\n"
    action 200 puts "No more bottles of beer on the wall, "
    action 210 puts "no more bottles of beer."
    action 220 puts "Go to the store and buy some more, "
    action 230 puts "99 bottles of beer on the wall.\n"
!
alias exec sing event manager run 99-bob
```

Setting a Variable

While Loop – {

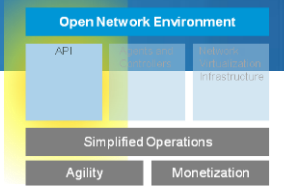
Decrementing a Variable

While Loop – }

Referencing a Variable

Using an Alias to run our Applet

See also: http://www.99-bottles-of-beer.net/language-cisco-ios-embedded-event-manager-applet-2909.html



Packaging Network Automations

Problem: Cisco IOS Embedded Automation Systems often include multiple configuration items, files, checks and procedures – how to ensure they are deployed consistently?

Solution: Cisco EASy provides a simple packaging mechanism and open-source EASy Installer. A developer guide is available online to assist with the creation of EASy packages.

- Package Description
- Pre-Requisite Verification
- Pre-Installation Config
- Pre-Installation Exec
- Environment Variables
- Configuration
- Files
- Post-Requisite Verification
- Post-Installation Config
- Post-Installation Exec
- Uninstall

EASy Installer + MyPackage.tar = Menu Guided Installation

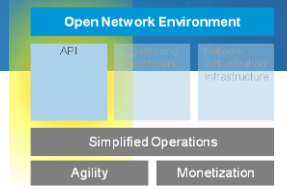
```
Router# easy-installer tftp://10.1.1.1/mypackage.tar flash:/easy
------------------------------------------------------------------
Configure and Install EASy Package 'mypackage-1.03'
------------------------------------------------------------------
1. Display Package Description
2. Configure Package Parameters
3. Deploy Package Policies
4. Exit

Enter option: 2
```

See: http://www.cisco.com/go/easy
EASy Package guide: http://tools.cisco.com/squish/cEAe3

Embedded Automation Systems (EASy)

For Your Reference

1. Browse and Download EASy Packages
   www.cisco.com/go/easy
2. Make Sure to also download EASy Installer
3. Browse Other Embedded Automations
   www.cisco.com/go/ciscobeyond
4. Learn About The Technology Under The Hood
   www.cisco.com/go/instrumentation
   www.cisco.com/go/eem
   www.cisco.com/go/pec
5. Discuss, Ask Questions, Suggest Answers
   supportforums.cisco.com
   supportforums.cisco.mobi
6. Upload your own Examples to CiscoBeyond
   www.cisco.com/go/ciscobeyond
7. Engage via ask-easy@cisco.com



Operational Network Automation

Business Operations

1

3

5

APIs and Agents

Domain Controllers

c

6

7

Virtual / Overlay Networks

b

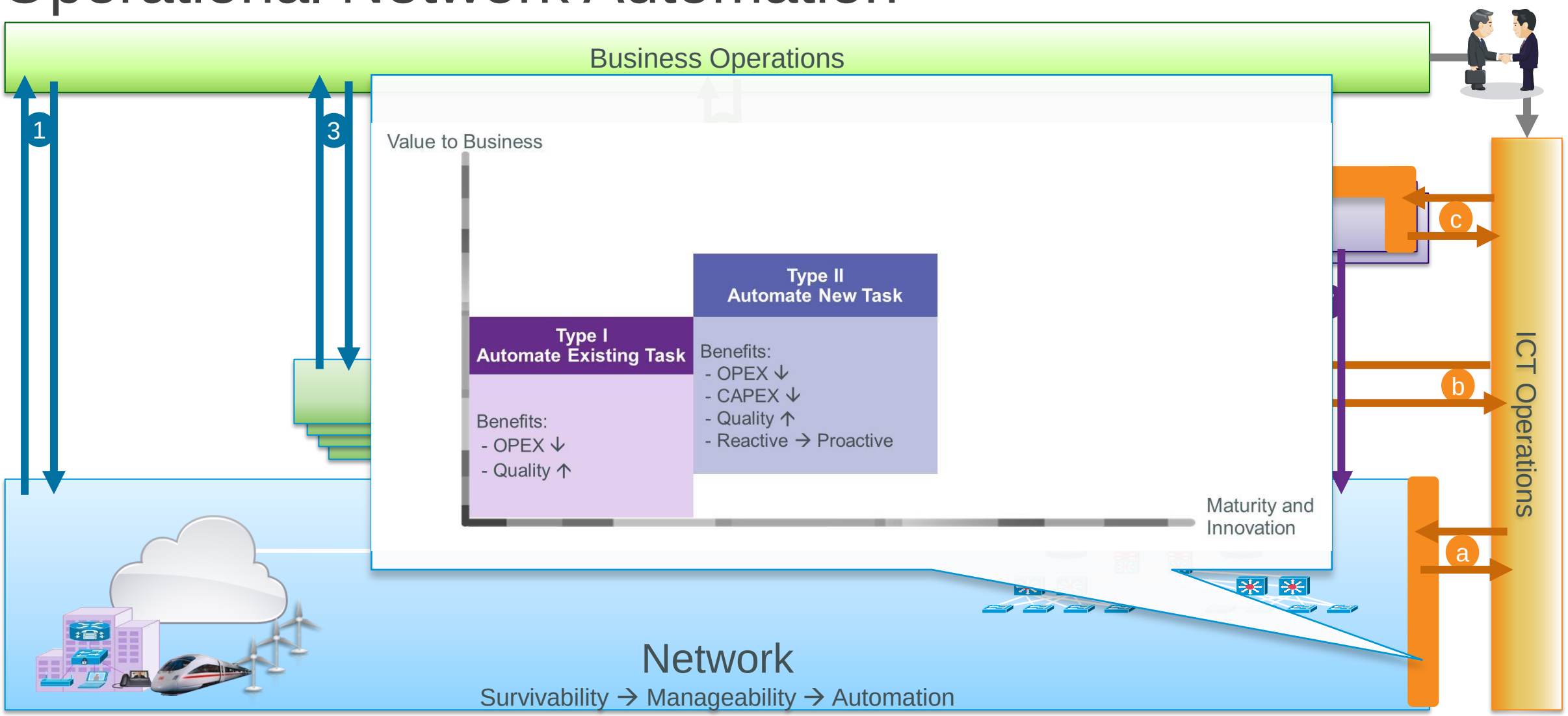
ICT Operations

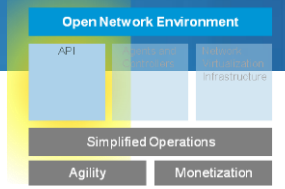
a

Network

Survivability → Manageability → Automation

Operational Network Automation





Inflection: Business-Driven Network Automations …

Business Operations

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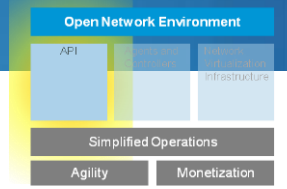
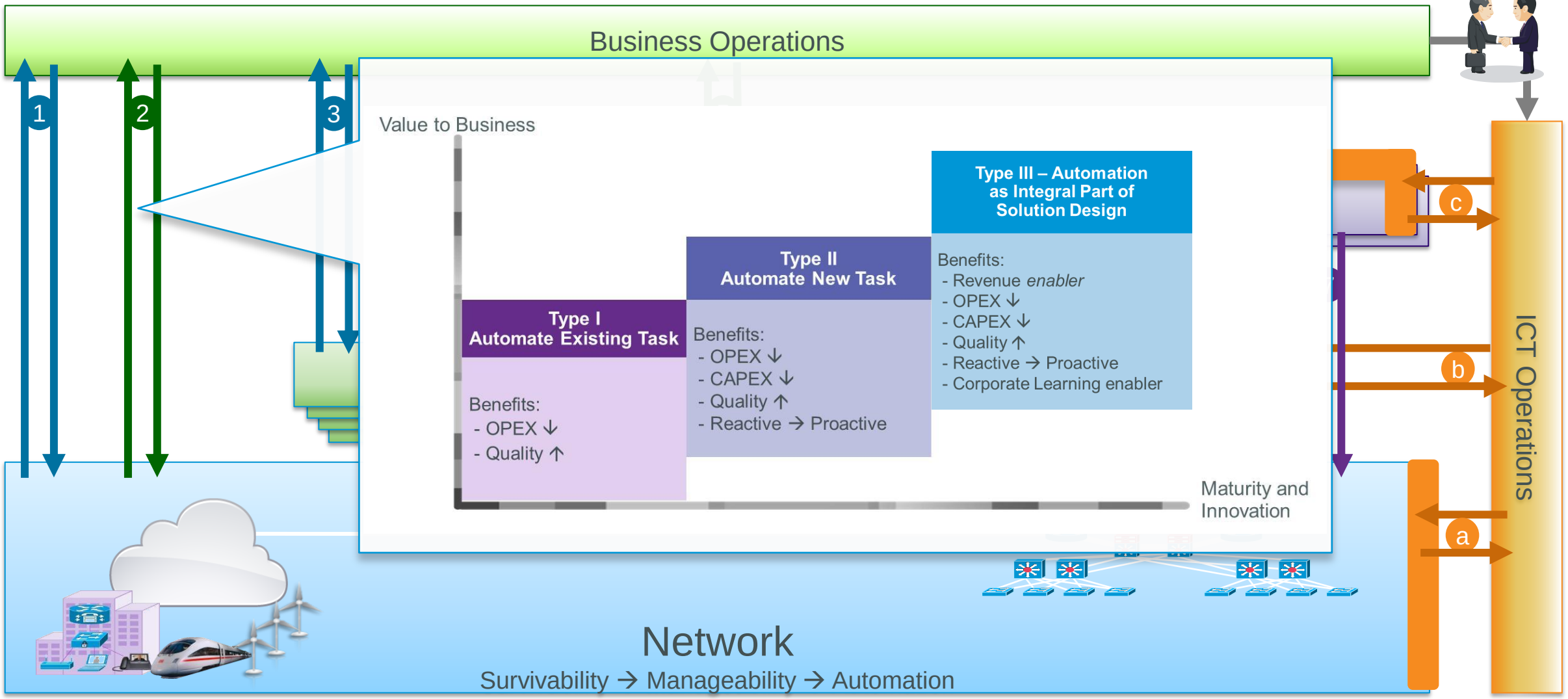


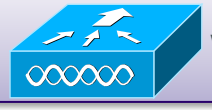


Self-Service for Human Users

Business Operations

1

3

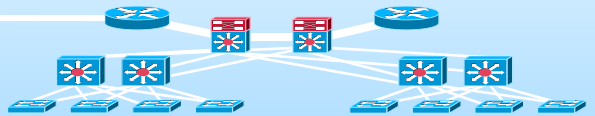


Wireless Controller(s) (WLC, etc, …)

ICT Operations

Virtual / Overlay Networks

b



a

Network

Survivability → Manageability → Automation

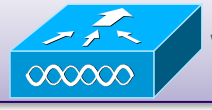
Self-Service for Human Users

Business Operations

1

3

Operations
(FCAPS)



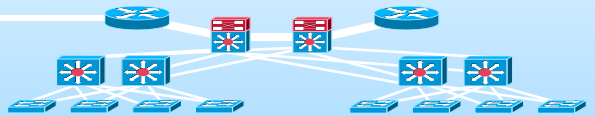
Wireless Controller(s) (WLC, etc, …)

c

Virtual / Overlay Networks

b

ICT Operations



a

Network

Survivability → Manageability → Automation

Self-Service for Human Users

Business Operations

1

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Operations
(FCAPS)

Wireless Controller(s) (WLC, etc, …)

c

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Resource
Allocation

7

Virtual / Overlay Networks

b

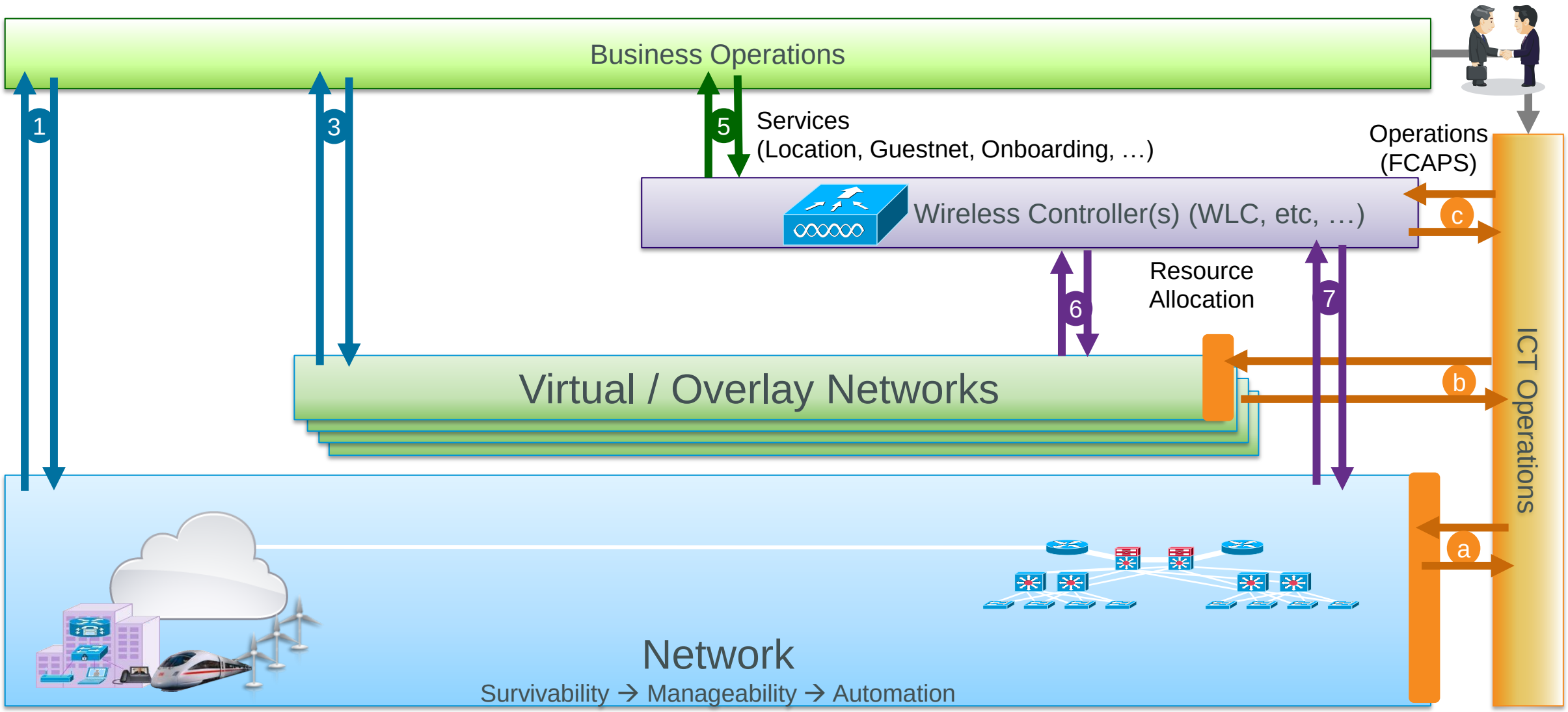
ICT Operations

a

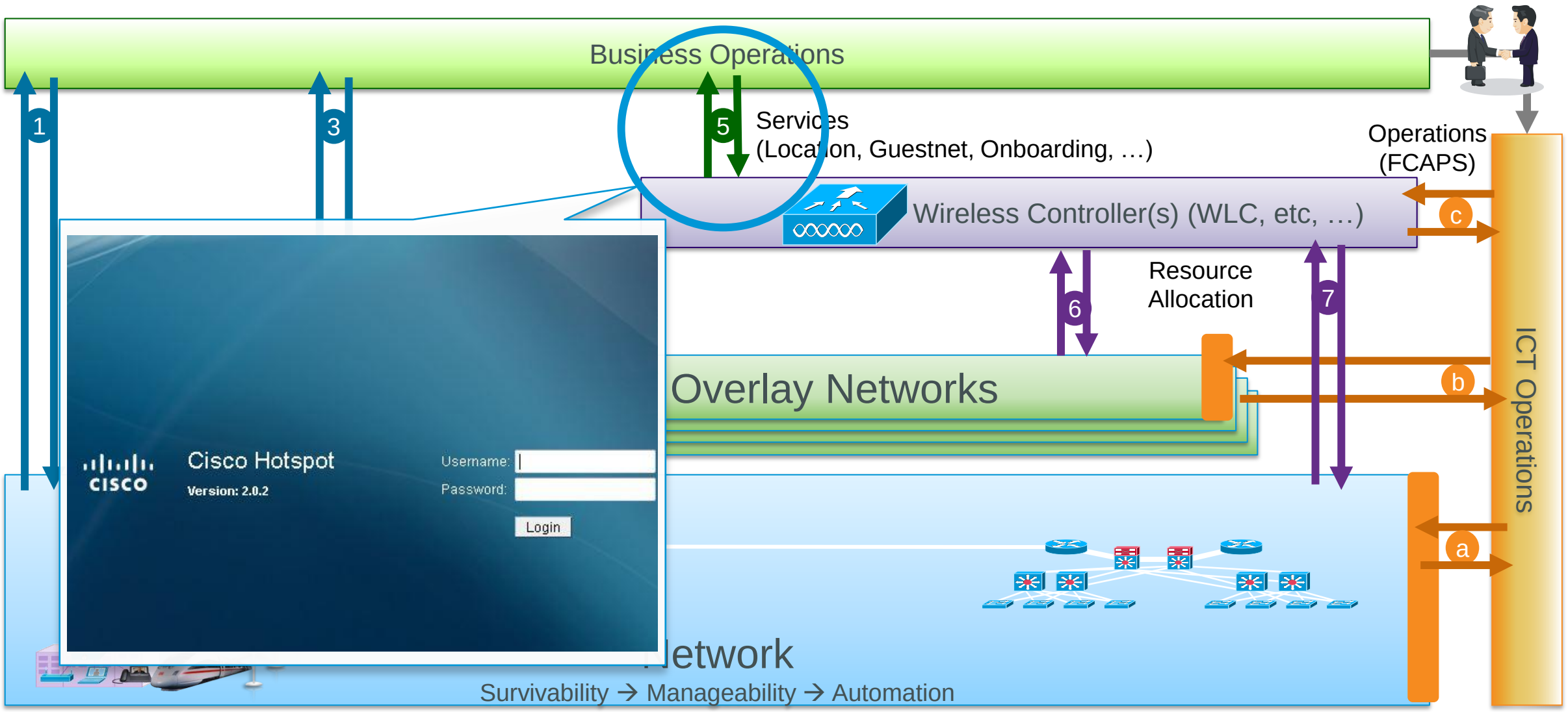
Network

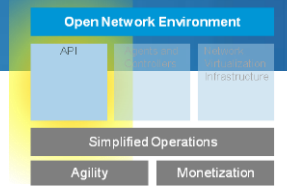
Survivability → Manageability → Automation

Self-Service for Human Users



Self-Service for Human Users





Inflection: Network Programming

Business Operations

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Virtual / Overlay Networks

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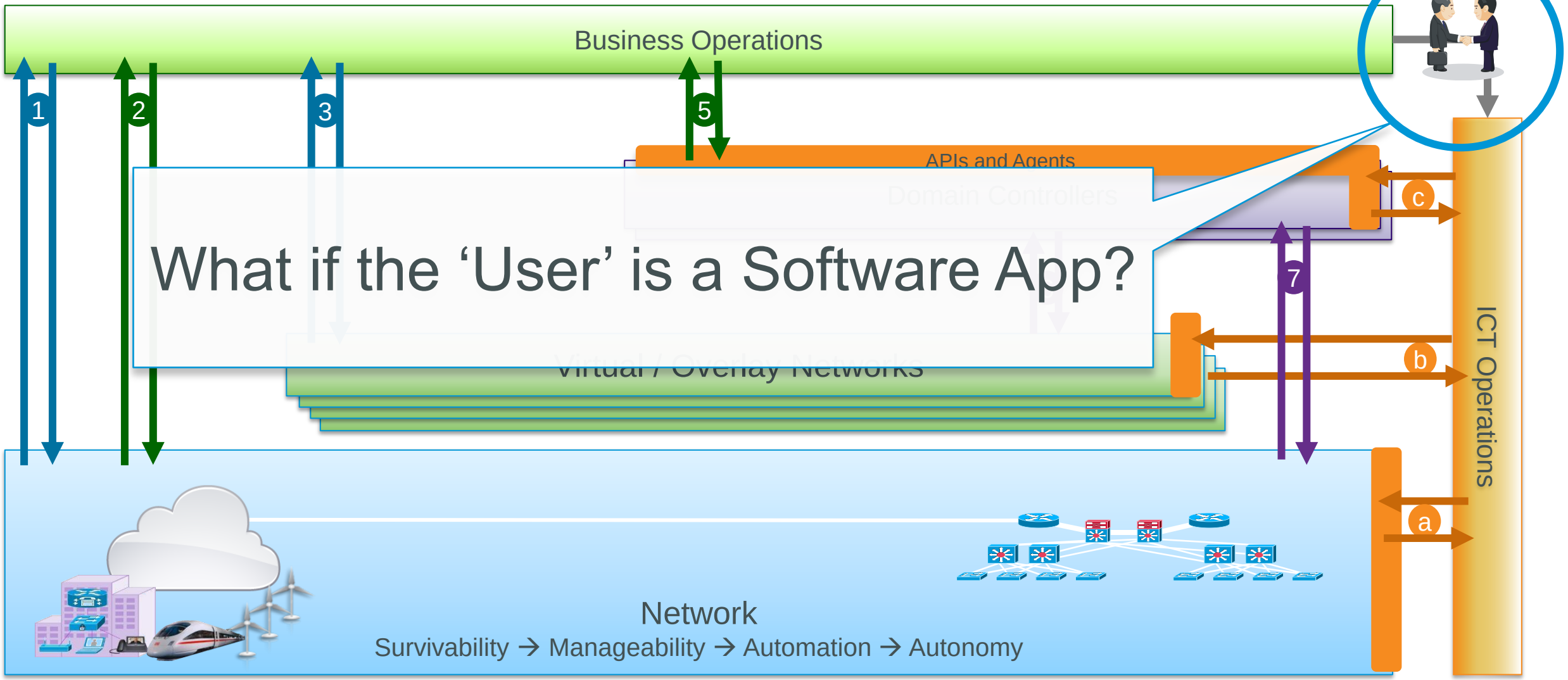
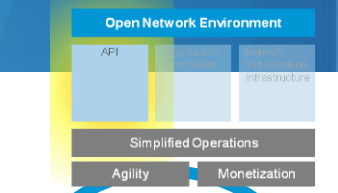
Network

Survivability → Manageability → Automation → Autonomy

Inflection: Network Programming

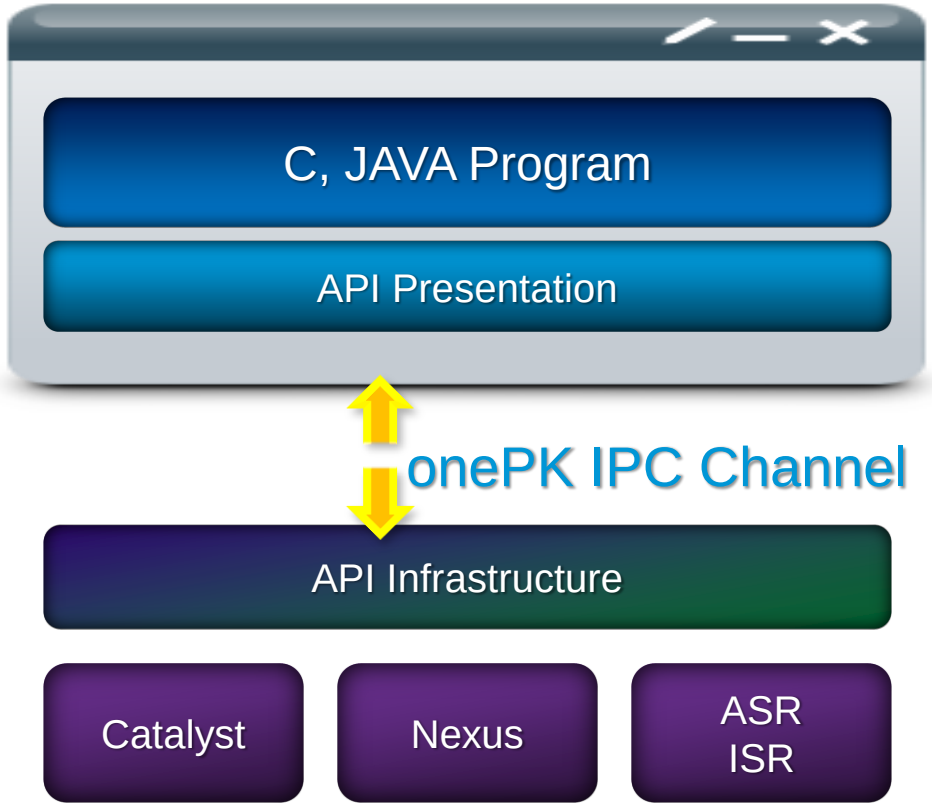


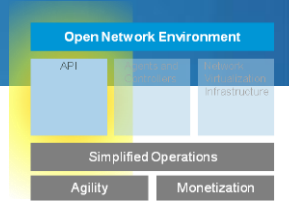


Cisco ONE Platform Kit (onePK)

Network Programming Environment to:

- Innovate
- Extend
- Automate
- Customize
- Enhance
- Modify





Cisco ONE Platform Kit (onePK)

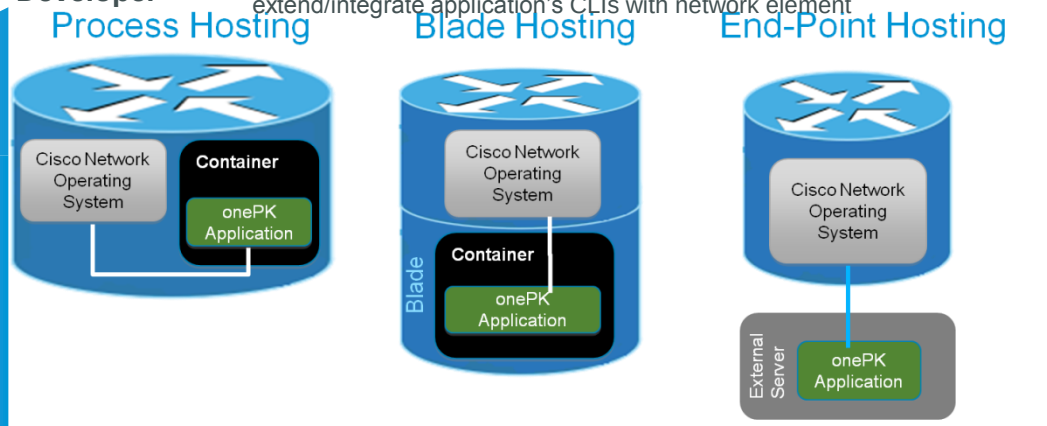
onePK Provides

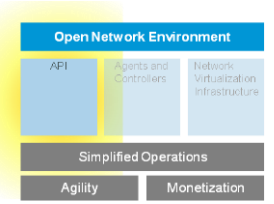
- Abstractions (Service Sets)
- Programmatic Interfaces (C, Java, (REST) …)
- Software Development Kit (SDK)

Service Set	Description	Version v.6.0.5 EFT 2012/2013
Data Path	Provides packet delivery service to application: Copy, Punt, Inject	
Policy	Provides filtering (NBAR, ACL), classification (Class-maps, Policy-maps), actions (Marking, Policing, Queuing, Copy, Punt) and applying policies to interfaces on network elements	
Routing	Read RIB routes, add/remove routes, receive RIB notifications	
Element	Get element properties, CPU/memory statistics, network interfaces, element and interface events	
Discovery	L3 topology and local service discovery	
Utility	Syslog events notification, Path tracing capabilities (ingress/egress and interface stats, next-hop info, etc.)	
Developer	Debug capability, CLI extension which allows application to extend/integrate application's CLIs with network element	

Anatomy of a onePK Application

- Software Application (currently C and Java)
- Interfaces and Abstractions (Service Sets)
- Communication Bus (Thrift IDL)
- Connected-Apps Agent in Network OS
- Network OS Features and Embedded Automations





Network Programming
Cisco ONE Platform Kit (onePK)

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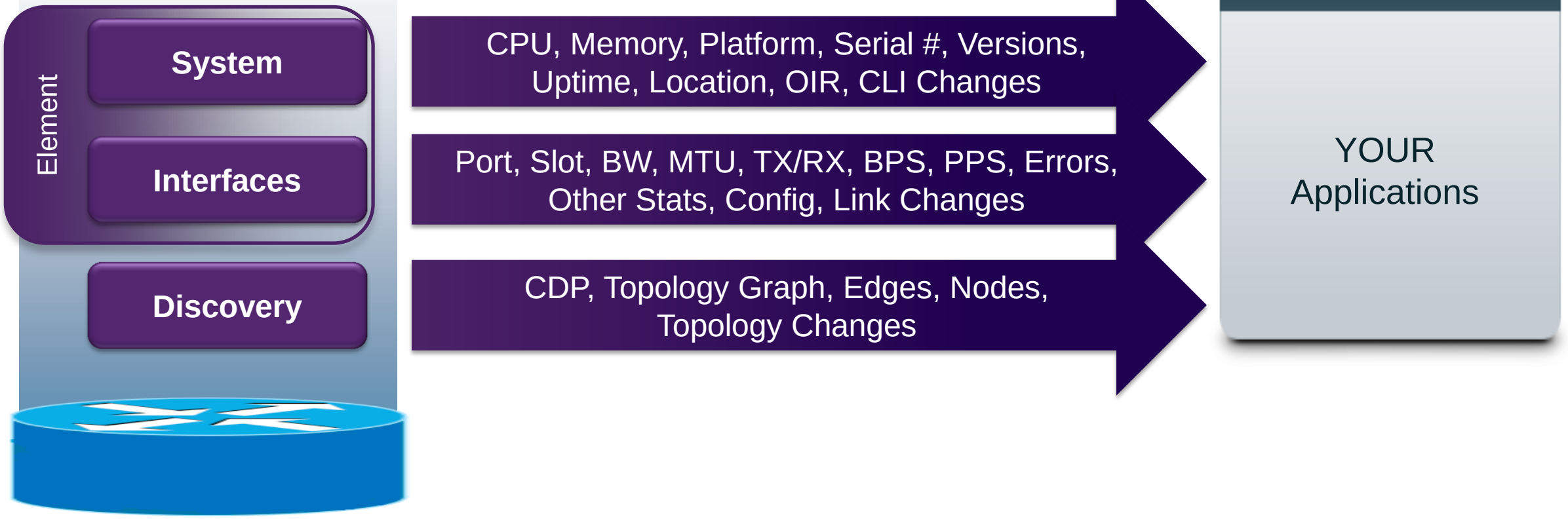
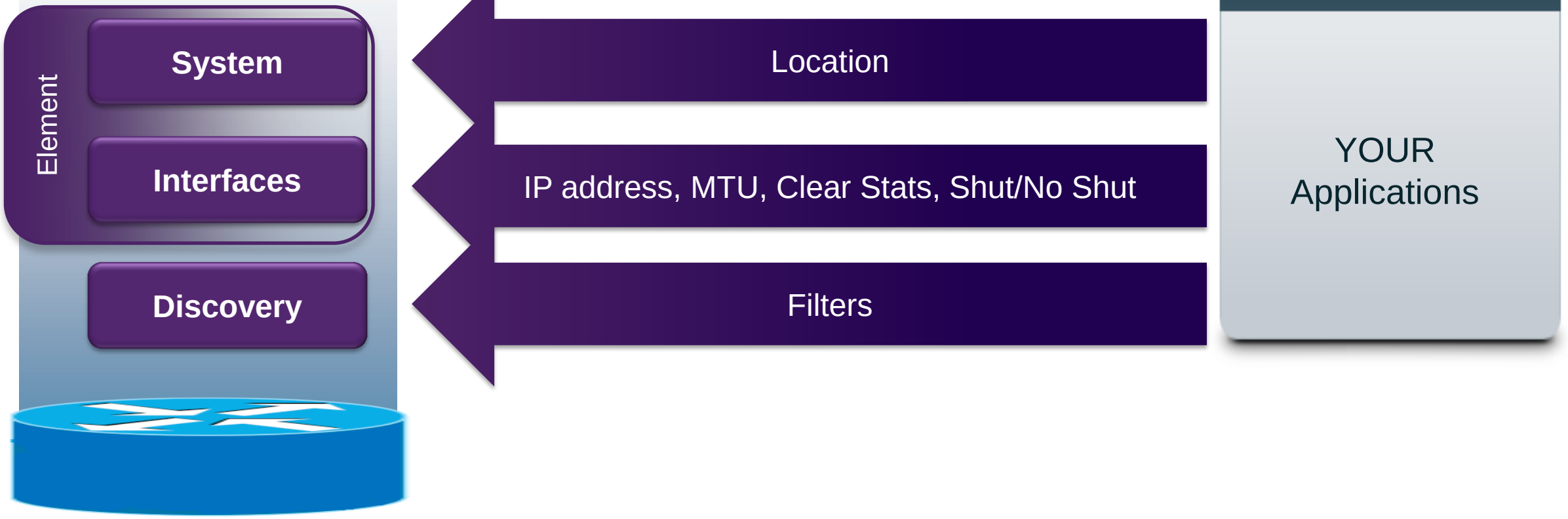
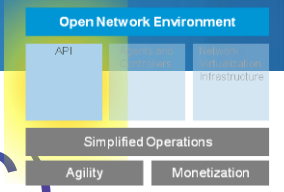
onePK Service Sets – Element Properties – 1/2



onePK Service Sets – Element Properties – 2/2





Example: Connect and Get Properties via onePK (C)

```
char *str = NULL;
onep_element_connect(elemA, user, pwd, NULL, &sh);
onep_element_get_property(elemA, &property);
if (property) {
      onep_element_to_string(elemA, &str);
            if (str) {
                fprintf(stderr, "\nElement Info: %s\n", str);
                free(str);
            }
}
```

```
Successful connection to network element

Element Info:
NetworkElement [ 172.20.165.44 ]
        Product ID    : ASR1001
        Processor     : 1RU
        Serial No     : SSI16050CJ5
        sysName       : ASR1K
        sysUpTime     : 546414
        sysDescr      : Cisco IOS Software, IOS-XE Software (X86
IVERSAL-M), Experimental Version 15.3(20120510:014633) [mcp_dev
LATEST_20120510_002552-ios 157]
Copyright (c) 1986-2012 by Cisco Systems, Inc.
Compiled Wed 09-May-12 21:44 by mcpre
```

Monitor Memory Usage

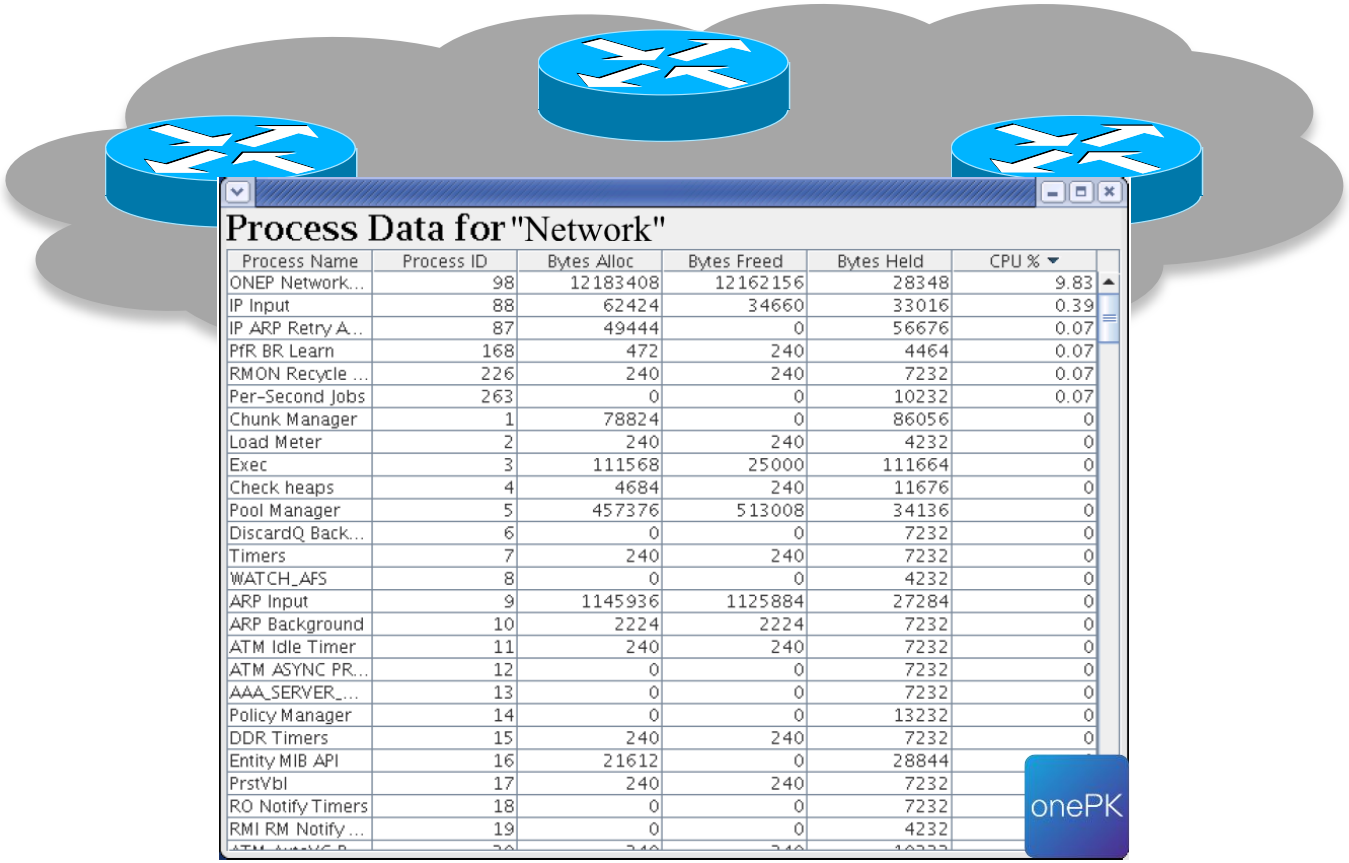
Problem: What if we need to dynamically investigate further upon a resource symptom ?

Solution: Use the integration of EEM + ERM to trigger an EEM event when processor memory is greater than 80%

```
resource policy
 policy critmem global
  system
   memory processor
    critical rising 80
interval 5
 user global critmem
```

```
event manager applet totmemcheck
 event resource policy critmem
 action 100 mail server "<server>" to "<to>" from "<from>" subject
"Warning: proc memory spike"
```

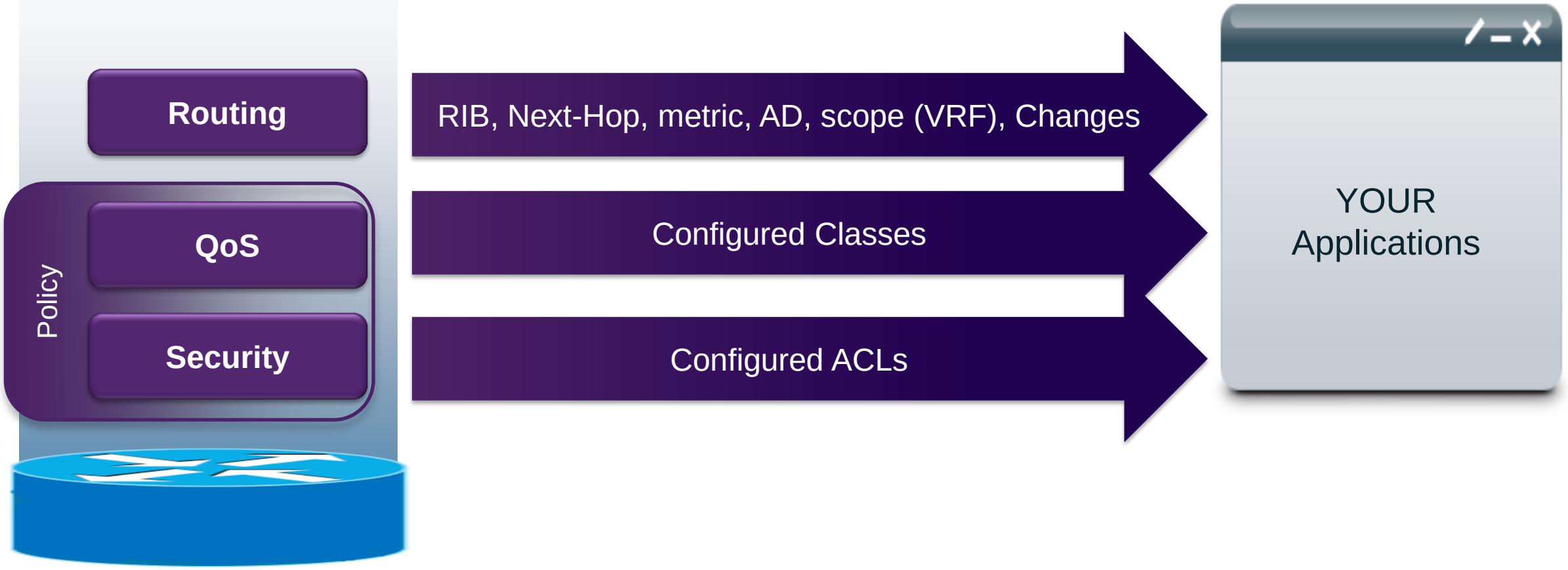
A Network “Top”



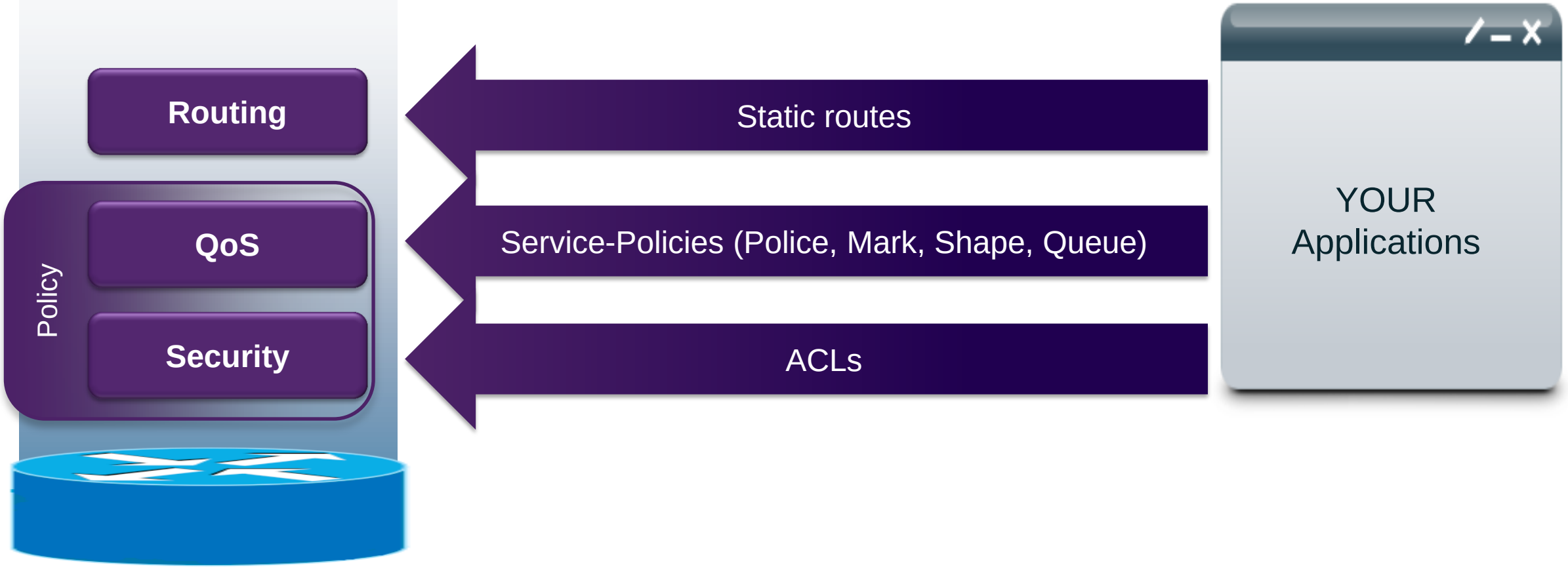
Use onePK to build a live process monitor similar to UNIX *top*

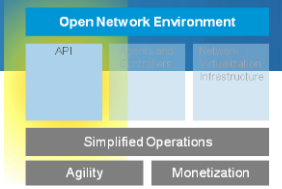
The same app can connect to multiple devices to display the top processes across the entire network

onePK Service Sets – Policy and Routing – 1/2



onePK Service Sets – Policy and Routing – 2/2





Example: Get and Set Routes via onePK (Java)

- Getting Routes

```
L3UnicastScope scope = new L3UnicastScope("", AFIType.IPV4, SAFIType.UNICAST, "");
NetworkPrefix prefix = new NetworkPrefix(InetAddress.getByName("0.0.0.0"), 0);
L3UnicastRIBFilter ribFilter = new L3UnicastRIBFilter(OwnerType.NONE, "NONE", prefix);
L3UnicastRouteRange range = new L3UnicastRouteRange(prefix, RouteRange.RangeType.EQUAL_OR_LARGER, 100);
List<TopoNode> mynodes = TopoNode.getAllNodes();
for(TopoNode thisnode : mynodes) {
    Routing routing = Routing.getInstance(thisnode.ne);
    RIB rib = routing.getRib();
    List<Route> routeList = rib.getRouteList(scope, ribFilter, range);
    for (Route route : routeList) {
```

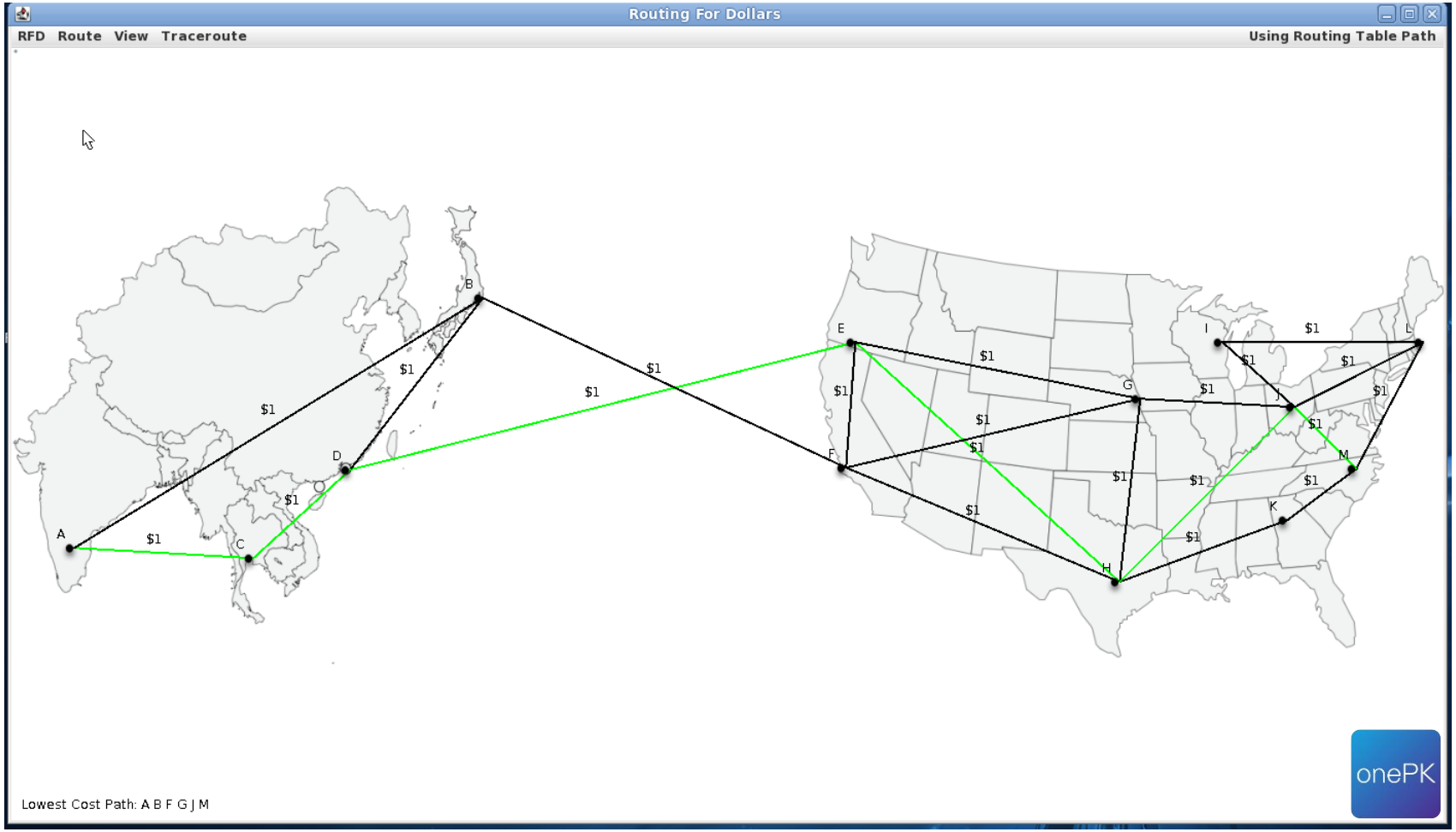
- Setting Routes

```
L3UnicastRoute aRoute = new L3UnicastRoute(prefix, nextHopList);
aRoute.setAdminDistance(1);
RouteOperation op = new L3UnicastRouteOperation(RouteOperationType.ADD, aRoute);
List<RouteOperation> opList = new ArrayList<RouteOperation>();
opList.add(op);
AppRouteTable art = routing.getAppRouteTable();
art.updateRoutes(scope, opList);
```

Example: Routing for Dollars / CO_2 / Tulips /…

Setup

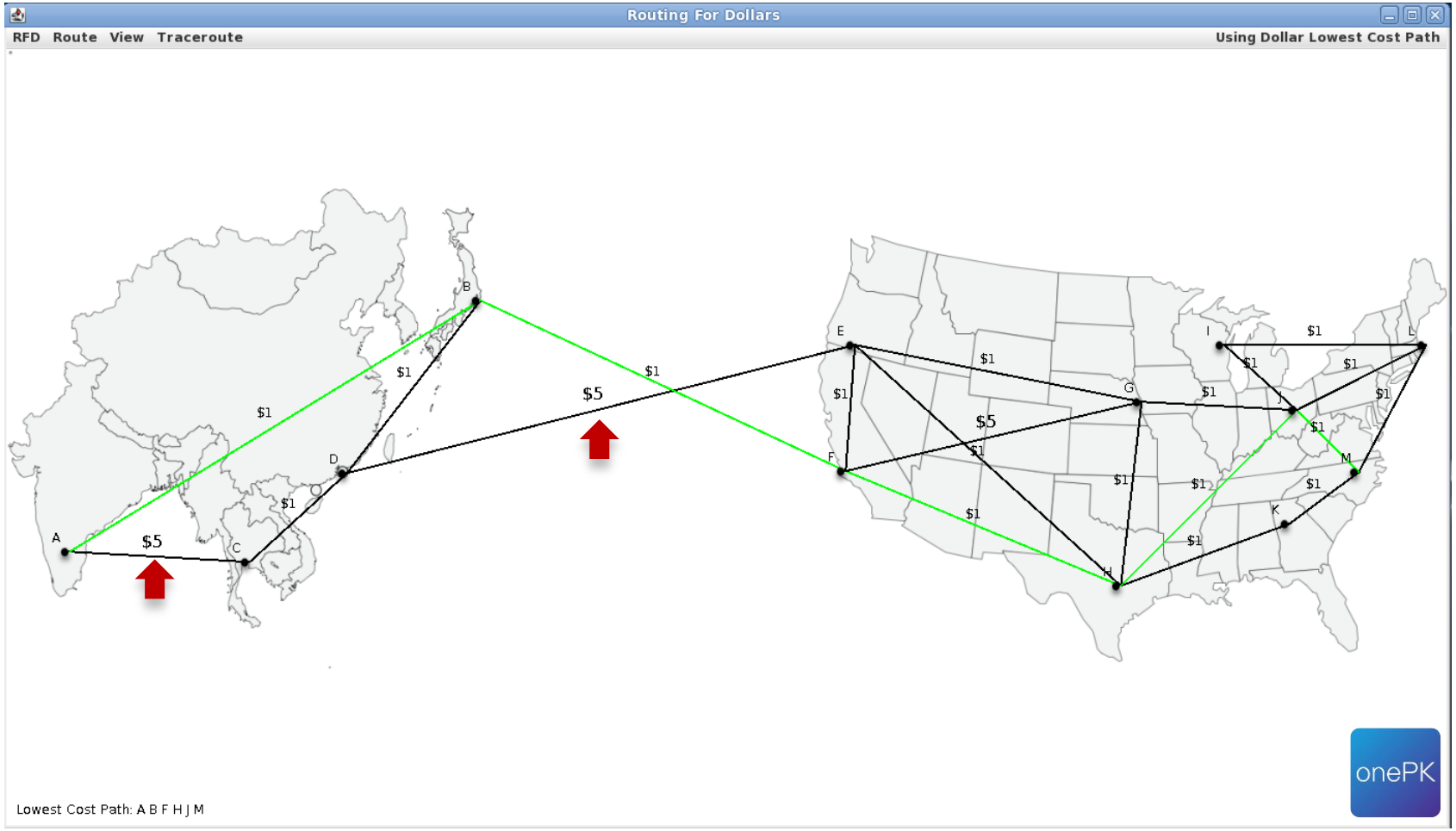
- EIGRP
- Routing Topology
- No External Metrics
- No External Algorithm



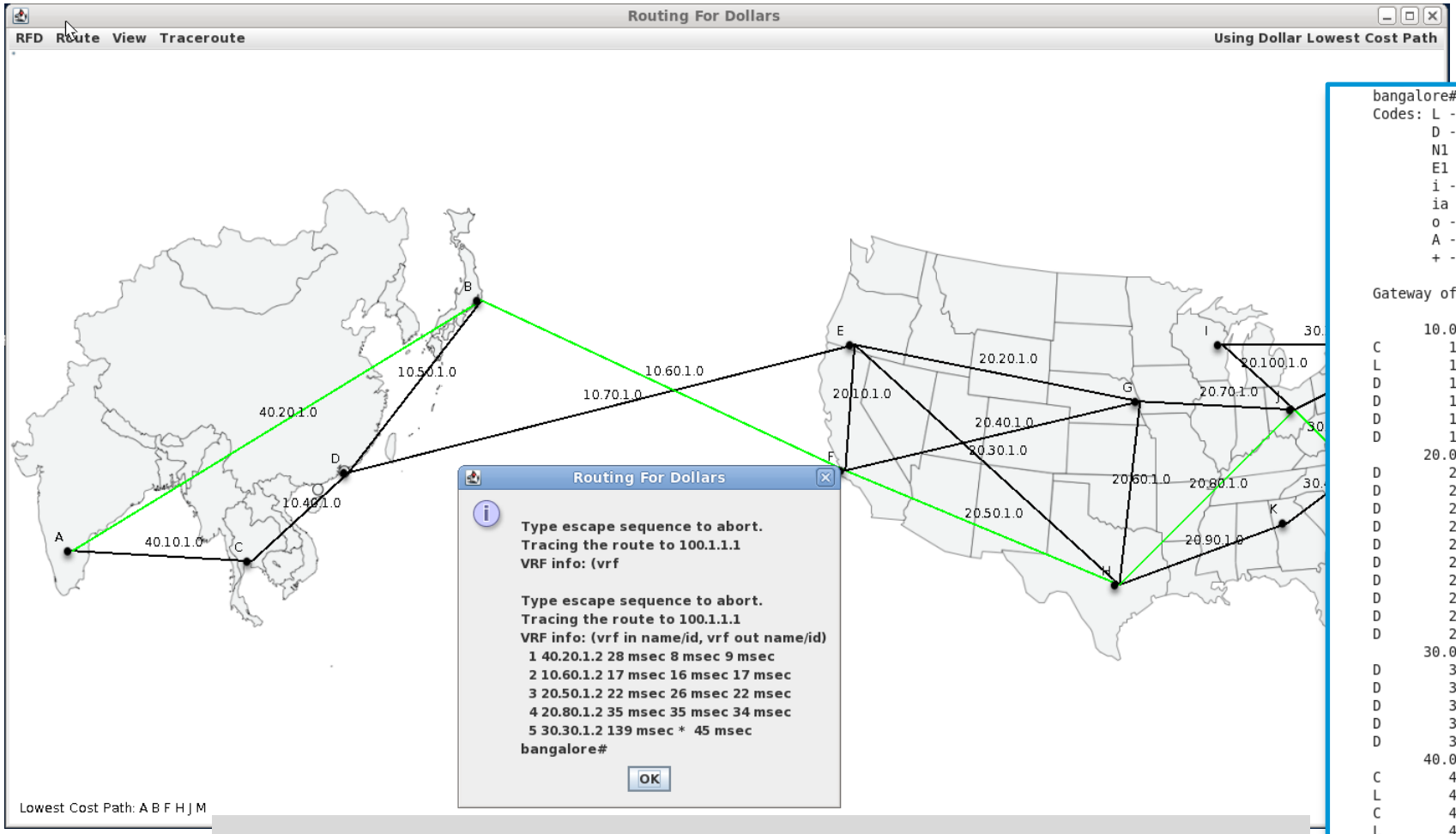
Example: Routing for Dollars / CO_2 / Tulips /…

Application Routes

- EIGRP
- onePK
- External Metrics
- External Algorithm



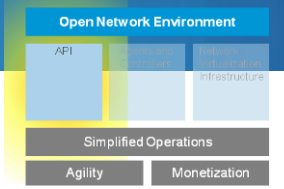
Example: Routing for Dollars / CO_2 / Tulips /…




```
bangalore#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       A - application route
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C        10.1.1.0/24 is directly connected, Ethernet0/0
L        10.1.1.4/32 is directly connected, Ethernet0/0
D        10.40.1.0/24 [90/2681856] via 40.10.1.2, 2w1d, Serial2/0
D        10.50.1.0/24 [90/3193856] via 40.10.1.2, 2w1d, Serial2/0
D        10.60.1.0/24 [90/3705856] via 40.10.1.2, 2w1d, Serial2/0
D        10.70.1.0/24 [90/3193856] via 40.10.1.2, 2w1d, Serial2/0
      20.0.0.0/24 is subnetted, 10 subnets
D        20.10.1.0 [90/3705856] via 40.10.1.2, 2w1d, Serial2/0
D        20.20.1.0 [90/4729856] via 40.10.1.2, 2w1d, Serial2/0
D        20.30.1.0 [90/3705856] via 40.10.1.2, 2w1d, Serial2/0
D        20.40.1.0 [90/4217856] via 40.10.1.2, 2w1d, Serial2/0
D        20.50.1.0 [90/4217856] via 40.10.1.2, 2w1d, Serial2/0
D        20.60.1.0 [90/4217856] via 40.10.1.2, 2w1d, Serial2/0
D        20.70.1.0 [90/4729856] via 40.10.1.2, 2w1d, Serial2/0
D        20.80.1.0 [90/4217856] via 40.10.1.2, 2w1d, Serial2/0
D        20.90.1.0 [90/6265856] via 40.10.1.2, 2w1d, Serial2/0
D        20.100.1.0 [90/4729856] via 40.10.1.2, 2w1d, Serial2/0
      30.0.0.0/24 is subnetted, 5 subnets
D        30.10.1.0 [90/5241856] via 40.10.1.2, 2w1d, Serial2/0
D        30.20.1.0 [90/4729856] via 40.10.1.2, 2w1d, Serial2/0
D        30.30.1.0 [90/4729856] via 40.10.1.2, 2w1d, Serial2/0
D        30.40.1.0 [90/5241856] via 40.10.1.2, 2w1d, Serial2/0
D        30.50.1.0 [90/5241856] via 40.10.1.2, 2w1d, Serial2/0
      40.0.0.0/8 is variably subnetted, 4 subnets, 2 masks
C        40.10.1.0/24 is directly connected, Serial2/0
L        40.10.1.1/32 is directly connected, Serial2/0
C        40.20.1.0/24 is directly connected, Serial2/3
L        40.20.1.1/32 is directly connected, Serial2/3
      100.0.0.0/24 is subnetted, 1 subnets
A        100.1.1.0 is directly connected, 00:01:56, Serial2/3
bangalore#
```

onePK

```
router ospf 1
redistribute application  <app name> ...
```



Example: Routing for Dollars / CO_2 / Tulips /…

Statistics and Metrics

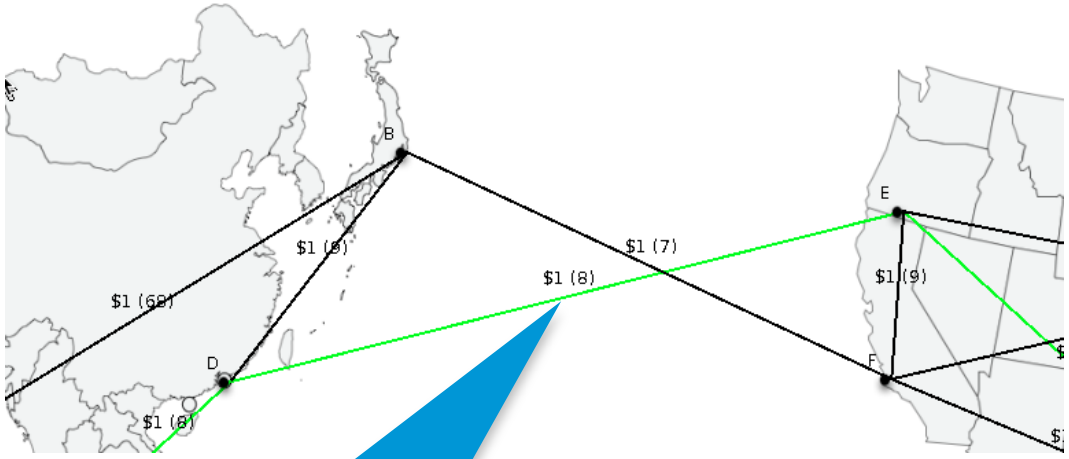
- Code Metrics
  - Total lines of code: 4700 (JAVA)
  - 40% SWING GUI
  - 20% Dijkstra's algorithm, lowest cost path determination
  - 25% Housekeeping: Node and link database
  - 15% Calls to onePK infrastructure + error checking
- Code increase to add "Latency based routing" on top of "Routing for Dollars"
  - 100 lines of code
- Modular code base written in Java has allowed us to port this to mobility client.

Framework makes it easy to modify code and change business logic.

Modular java code makes it easy to deploy on multiple clients.

Example: Routing for Dollars / CO_2 / Tulips /…

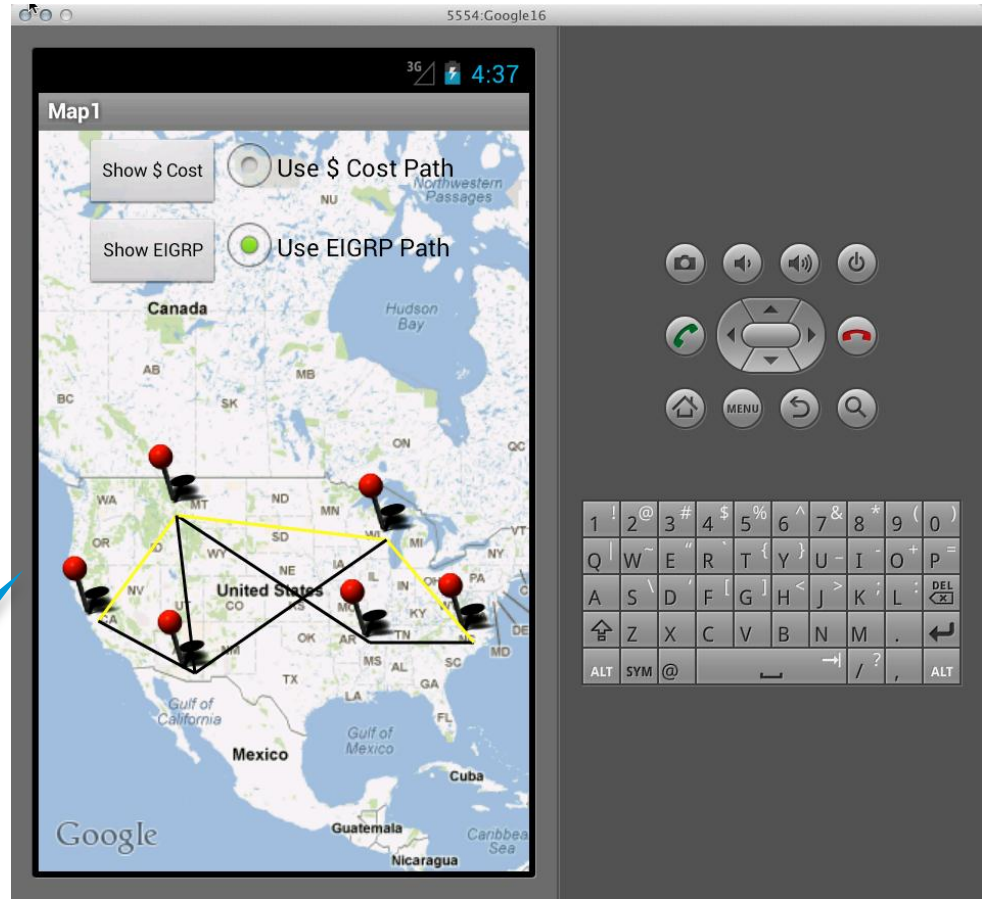
Recent Extensions

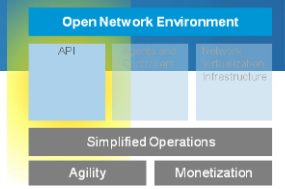


Path determination based on lowest latency

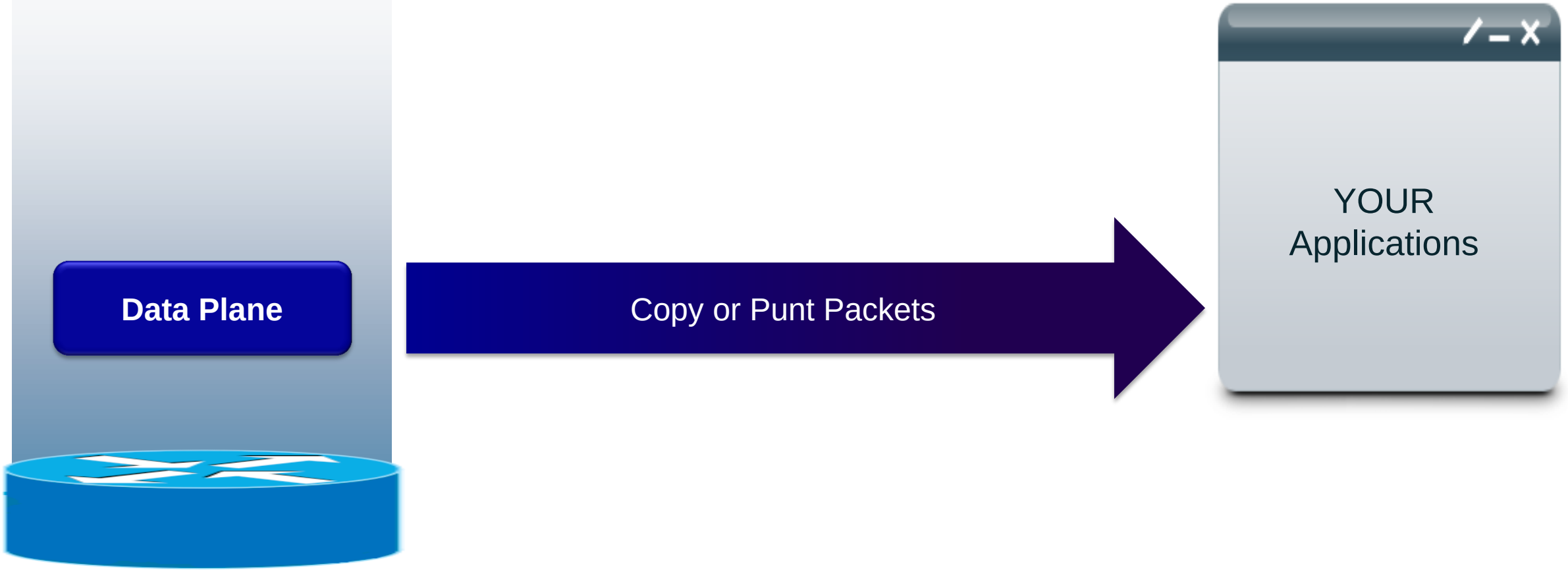
Latency information fed into app through IPSLA

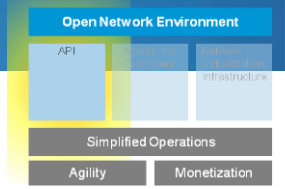
Port to mobility client



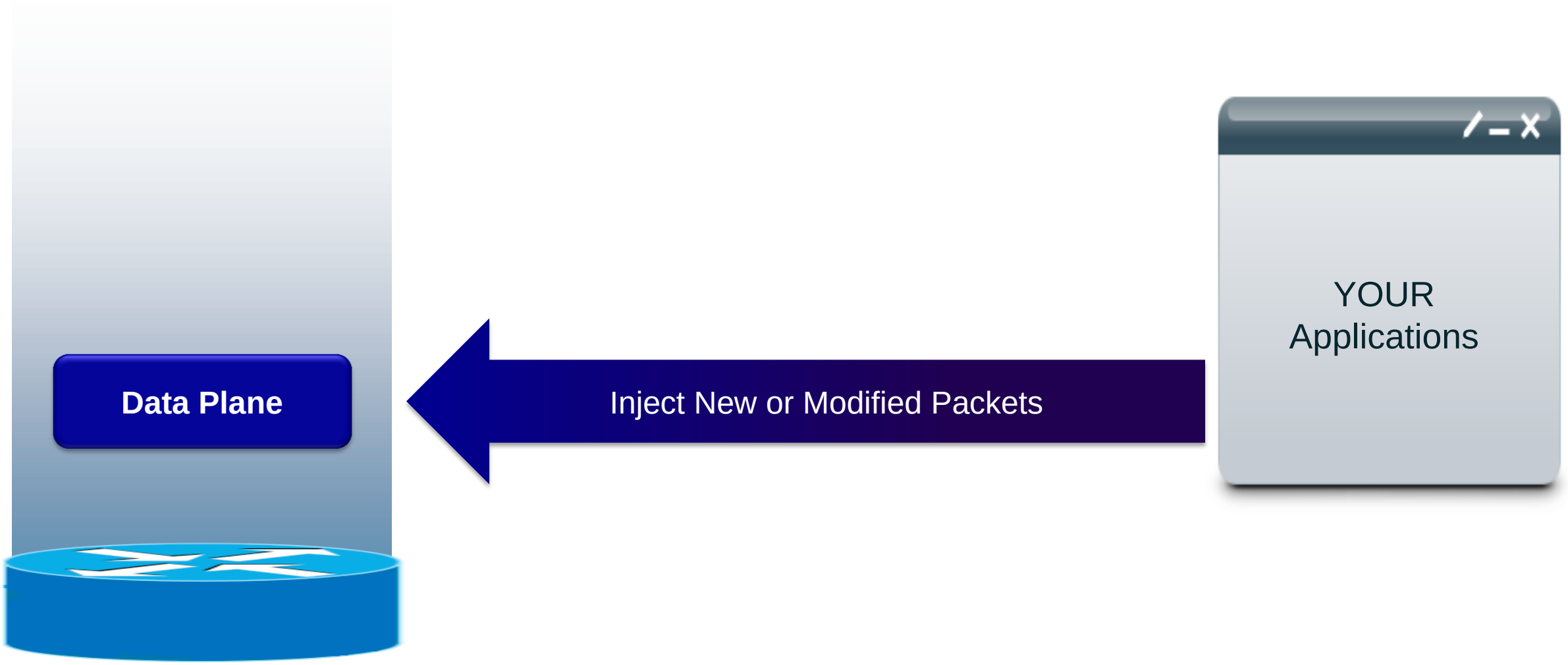


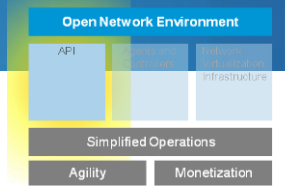
onePK Service Sets – Data Path – 1/2





onePK Service Sets – Data Path – 2/2





Example: Punt and Inject Packets via onePK (C)

```
TRY(rc, onep_dpss_register_for_packets(
                    ne1,
                    dpss,
                    targ_left,
                    interesting_class,
                    ONEP_DPSS_ACTION_PUNT,
                    encrypt_callback,
                    (void *)intf_left,
                    &reg_handle), "Register for packets");
```

Defines traffic of interest

Action to take on interesting traffic

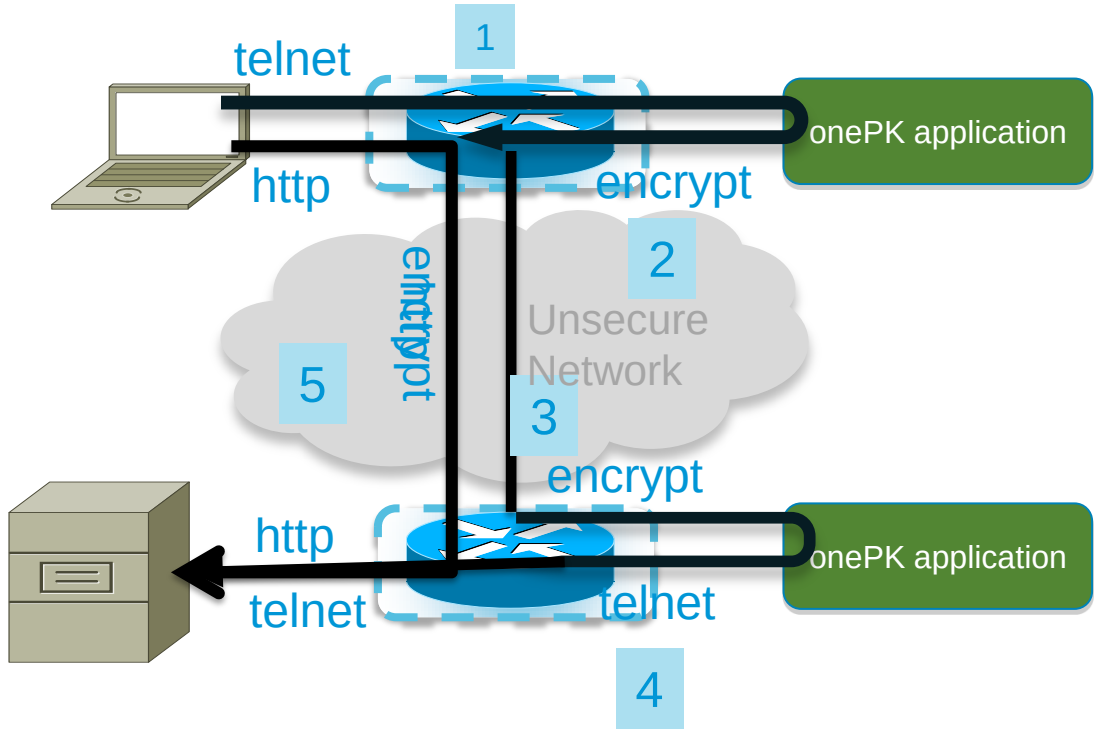
Where traffic goes next

Custom Application Traffic Flow Handling – 1/2

Problem: We need to custom encrypt packets of a specific application traffic flow

Solution: Use onePK to punt, encrypt and reinject the relevant packets

1. Policy APIs on ingress router are set to punt telnet and syslog to app
2. App encrypts punted traffic and re-injects into data path.
3. Policy APIs on egress router punt telnet and syslog to app
4. App decrypts punted traffic and re-injects into data path.
5. Traffic that does not match policy passes through unencrypted.

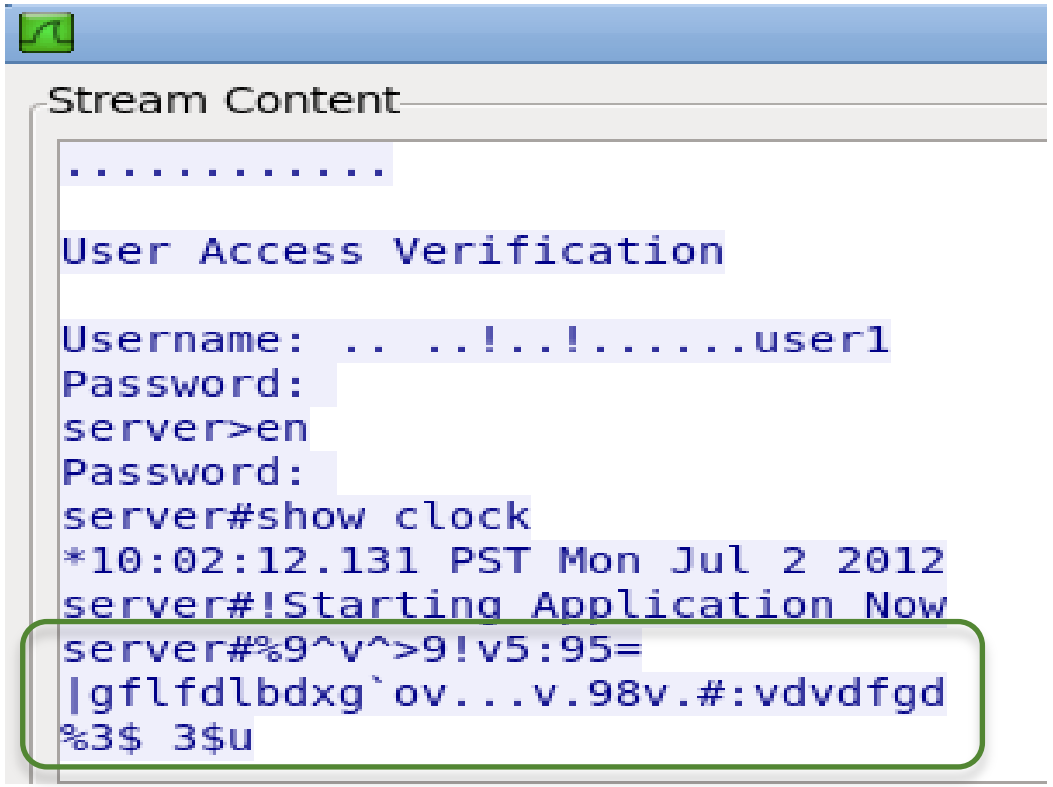


Custom Application Traffic Flow Handling – 2/2

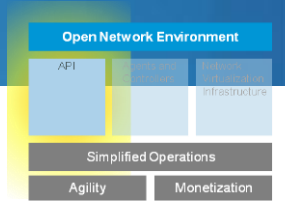
What Client Sees

```
client#telnet 10.13.1.1
Trying 10.13.1.1 ... Open


User Access Verification

Username: user1
Password:
server>en
Password:
server#show clock
*10:02:12.131 PST Mon Jul 2 2012
server#!Starting Application Now
server#show clock
*10:02:42.169 PST Mon Jul 2 2012
server#
```

What Wireshark Sees



onePK Agent ←→ Application Interactions



Examples:
- Getting 50'000 ACLs from an Element

Request + Filter
Block Result 1
Iterations ...
Iterator
iterative

Examples:
- Syslog Messages
- RIB Changes

Subscribe + Filter
Event
Event
Notification Handler
Publish Subscribe

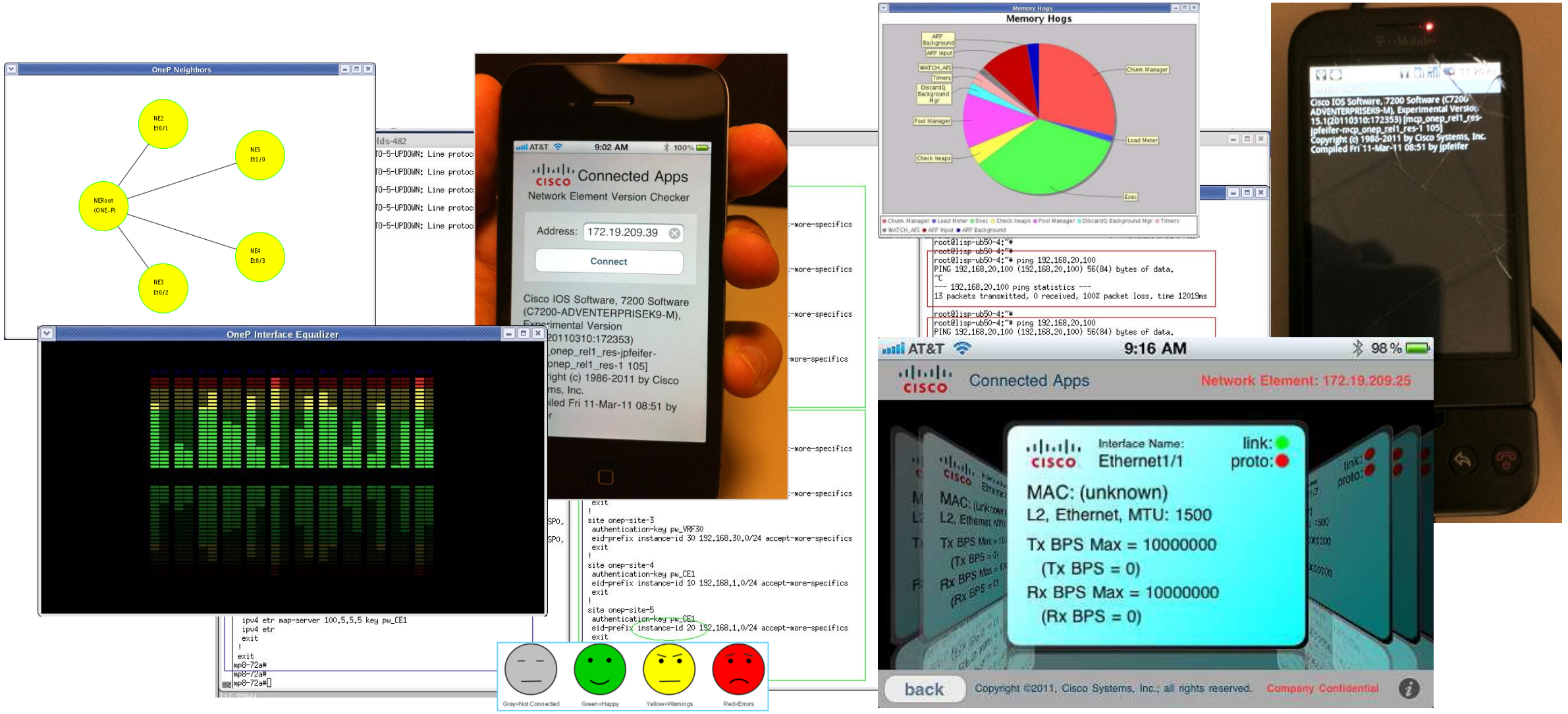
Examples:
- Setting 50'000 ACLs on an Element

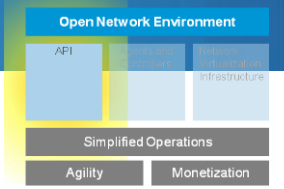
Call
Callback
Callback Function
Request Response

Examples:
- Get Element Version
- Set Interface Address

Call / Return
synchronous

What will YOU program ?





Portfolio of API, Languages and Abstractions

Network Programming with onePK and Embedded Network Automation

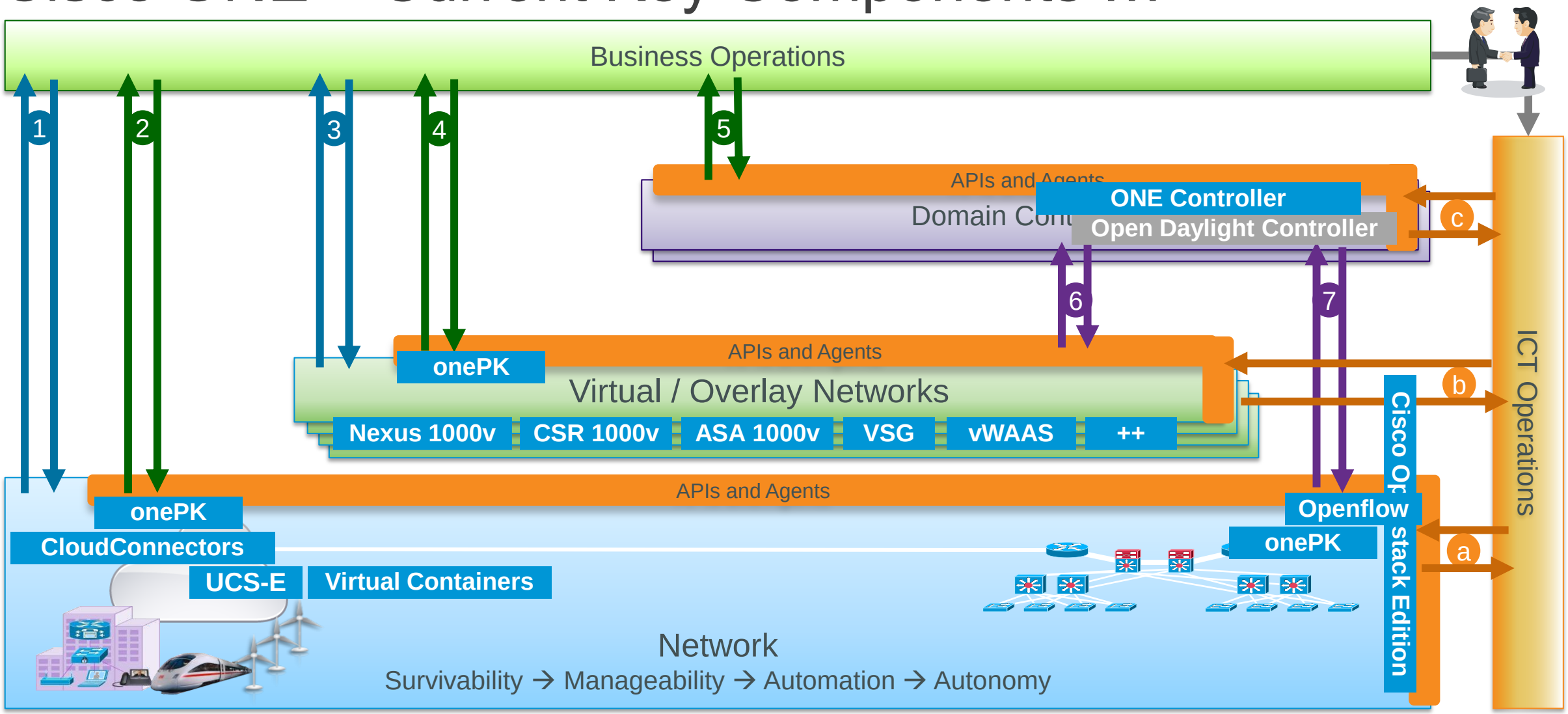
Native Network OS Embedded Automation	Advanced Network OS Embedded Scripting	Structured API	Object Oriented API	Higher-Level Abstractions / Interfaces
Event-/Expression- MIB, PfR, IPSLA Thresholds, Embedded Event Manager Applets, …	Tcl, Python, Embedded Event Manager, EASy, …	onePK C	onePK Java	onePK Libraries REST, XMPP, Design Patterns, OMNI Controllers, …

Network Programming – SDN

Network Automation – Embedded Automations

Choice and Flexibility of Implementation

Cisco ONE – Current Key Components …



Resources and References

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References – Programmable and Cloud-Intelligent

Cisco ONE – Open Network Environment: http://www.cisco.com/go/one

Cisco onePK – ONE Platform Kit: http://www.cisco.com/go/onepk

Cisco Developer Network: http://developer.cisco.com/web/onepk

Cisco EASy – Embedded Automation Solutions: http://www.cisco.com/go/easy

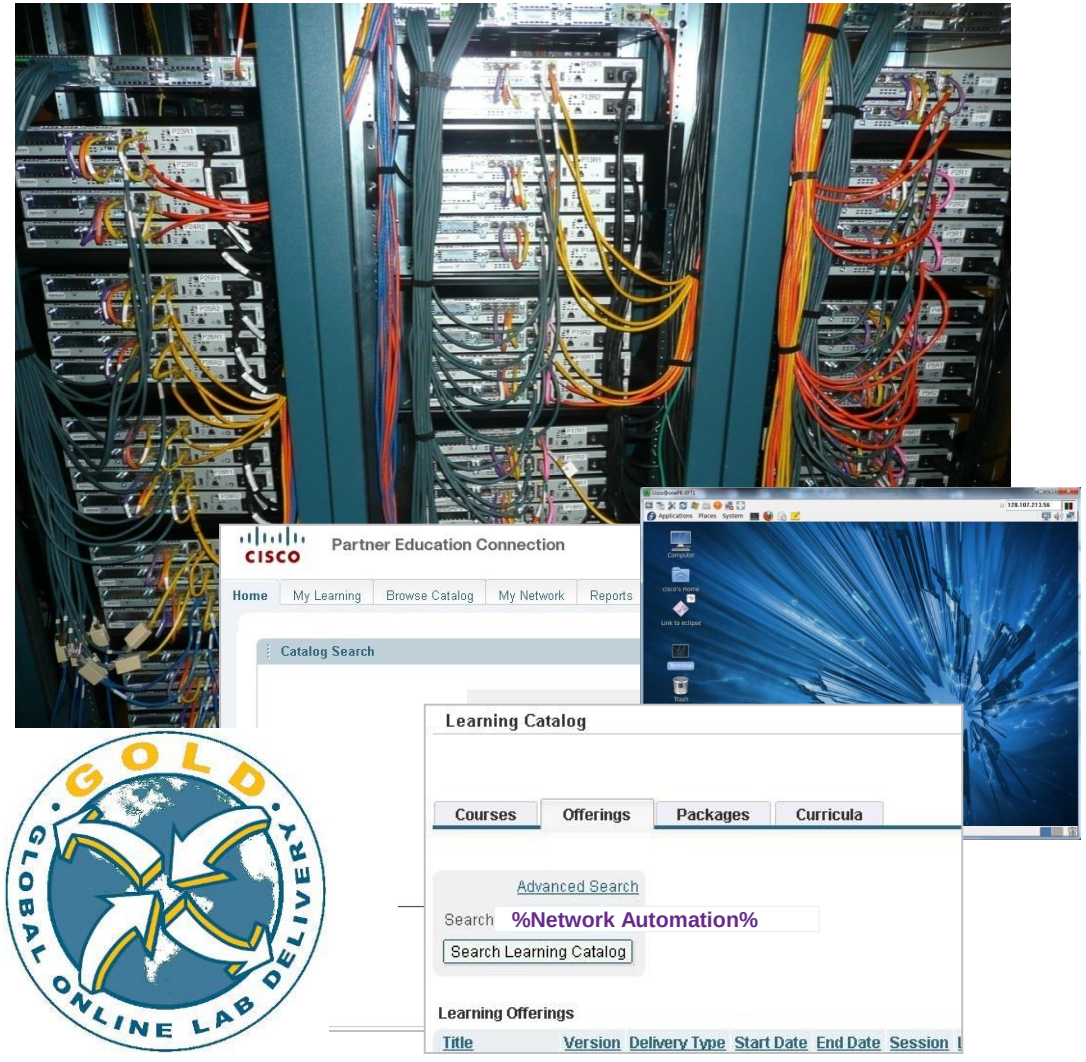
Cisco Scripting Community: www.cisco.com/go/ciscobeyond

Cisco Cloud Connectors – Blog: http://blogs.cisco.com/borderless/the-network-is-the-path-to-accelerate-adoption-of-cloud-services/

Cisco Cloud Connectors – Marketplace: https://marketplace.cisco.com/catalog/search?search[technology_category_ids]=938

Network Programming Hands-On Lab

For Your Reference



At CiscoLive: Join us for TECNMS-3601 Advanced Network Automation or

1. Walk up to the WISP Labs
2. Book a seat for:
   - Network Automation – The Basics
   - Network Automation – Intermediate
   - Network Automation – Advanced
   - Network Automation – Smart Call Home
   - Network Programming – The Basics
   - Network Programming – Intermediate
   - Network Programming – Advanced

Partners via PEC (currently being updated):

1. Navigate to http://www.cisco.com/go/pec
2. Click on >Launch
3. Search for ‚%Network Programming%‘
4. Enjoy !

Network Automation Hands-On Lab – 3 Levels

2 – Network Automation: Intermediate
Service Planning
  Task 211 – Exporting Bulk Statistics
  Task 222 – Exporting upon Periodical Time Windows
Service Deployment
  Task 221 – Installing an EASy Package – Extensible HTTP Server
  Task 222 – Creating an EASy Package – Hello World
  Task 223 – Configure Your Network for a onePK Application
  Task 224 – EASy Post-Deployment Manageability Verification
Service Monitoring
  Task 231 – Monitoring Resources – Using ERM and EEM
  Task 232 – Monitor Application Traffic using Flexible NetFlow - NBAR Integration
  TBC Task 233 – Monitoring SLA – Using Cisco IOS Auto IPSLA (+ IPSLA ED)
Service Troubleshooting
  Task 241 – Detecting Low-TTL Traffic
  Task 242 – Capturing Packets – Using Embedded Packet Capture
  Task 243 – Capturing Packets – Using the EASy EPC Package
  Task 244 – Logging SNMP Traps – Using the EASy Trap Logger

3 – Network Automation: Advanced
Service Planning
  Task 311 – EEM System Policies – Tune to Device's EEM Capacity
Service Deployment
  Task 321 – Using Tcl Libraries in EEM Policies – Pure Tcl
  Task 322 – Dynamically Configure from HTTP Input – Using a Pure Tcl Library
  Task 323 – Protect Your Intellectual Property – Signed Byte Code
Service Monitoring
  Task 331 – Send Syslog Upon Route Change – EEM Routing Event Detector
  Task 332 – Monitoring Resource Groups – Using ERM and EEM
  Task 333 – Collecting Reliable Metrics – Using DCM, IP SLA and EEM
Service Troubleshooting
  Task 341 – EEM Applet – Testing and Debugging EEM Policies

1 – Network Automation: The Basics
Task 101 – Working with EEM Applets – Hello World
Task 102 – Working with EEM Tcl Policies – Hello World
Task 103 – Working with EEM – CLI Event Detector
Task 104 – Working with EEM – Regular Expressions
Task 105 – Simple Command Logging – EEM CLI Event Detector
Task 106 – Custom Interface Failover – using EEM, IPSLA, and Enhanced Object Tracking (EOT)
Task 107 – Editing ASCII Files in IOS
Task 108 – Using the IOS HTTP Client
Task 199 – Sneak Peek: onePK Custom Routing Application

Network Programming Hands-On Lab – 3 Levels

more updates coming

3 – Network Programming: Advanced

- Task 491 – Simulating a Network – IOL and NETMAPs
- Task 492 – Connecting to a Simulated Network – IOLTunnel
- Task 611 – Introspection: Discover Service Sets supported

2 – Network Programming: Intermediate

- Task 521 – Application Interaction with Custom CLI
- Task 531 – Application Interaction with Embedded Event Manager

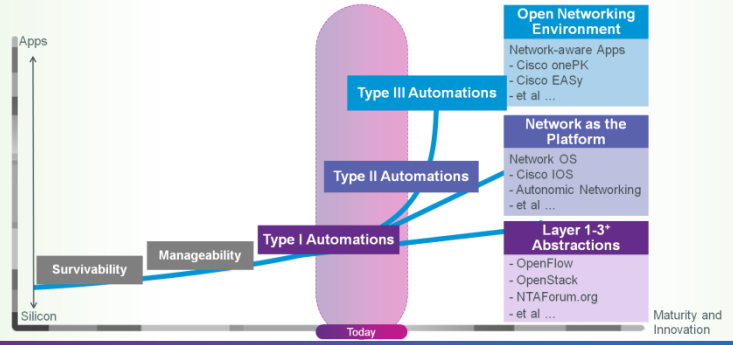
1 – Network Programming: The Basics

- Task 511 – Sample App: Deploy and Run a onePK Application from Eclipse
- Task 402 – Sample App: Routing for Dollars – Beyond Normal Routing Metrics
- Task 411 – Compile and Run a onePK C Application using make
- Task 412 – Compile and Run a onePK Java Application using mvn
- Task 421 – Create your own C onePK application
- Task 422 – Create your own Java onePK application

Master Class Network Programming and Automation

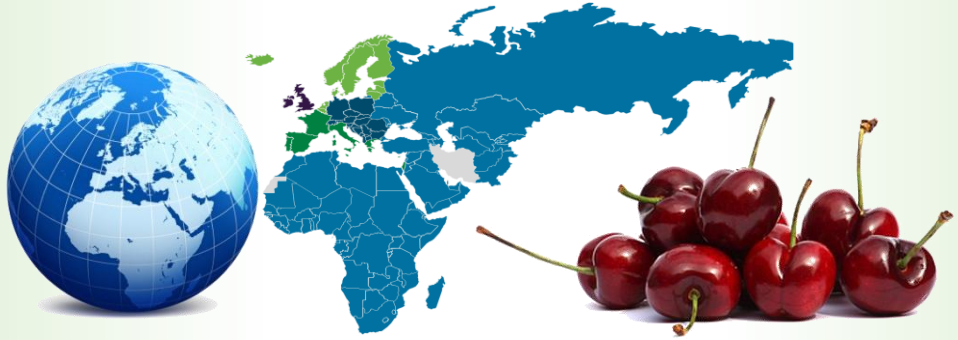
Sustainable Innovation and Differentiation with Cisco Embedded Automation and onePK

How can I successfully use Network Programming?



Step-by-step introduction and adoption strategies

What have other Customers and Partners done?



Real-Life Examples and Case Studies

Where do I start – can I do this?

```
public static void main(String args[]) {
  /**
   ** parse command line options
   **/
  parseCommandLine(args);
  System.out.println("\n *************** Start ***************\n");

  try {
    /**
     ** Instantiate a class object to begin with.
     **/
    HelloNetwork hn = new HelloNetwork();

    /**
     ** Connect to the network element.
     **/
    connect();
    System.out.println("Connect to element = " + elementAddr);
```

Practical Examples and Hands-on Lab

What are Cisco ONE and onePK anyhow?

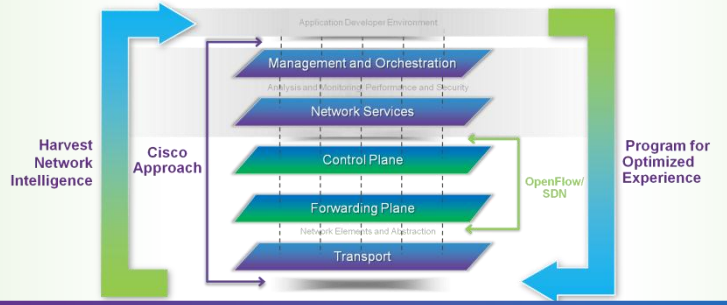


Illustration in the bigger SDN and Automation Context

Join us for the Network Programming Master Class Series

References – Instrumentation and Automation

For Your Reference

Device Manageability Instrumentation (DMI) www.cisco.com/go/instrumentation

- Embedded Event Manager (EEM): www.cisco.com/go/eem
- Cisco Beyond – EEM Community: www.cisco.com/go/ciscobeyond
- Embedded Menu Manager (EMM): http://tinyurl.com/emm-in-124t
- Embedded Packet Capture (EPC): www.cisco.com/go/epc
- Flexible NetFlow: www.cisco.com/go/netflow and www.cisco.com/go/fnf
- GOLD: http://www.cisco.com/en/US/products/ps7081/products_ios_protocol_group_home.html
- IPSLA (formerly SAA, formerly RTR): www.cisco.com/go/ipsla
- Network Analysis Module: http://www.cisco.com/go/nam
- Network Based Application Recognition (NBAR): www.cisco.com/go/nbar
- Security Device Manager (SDM): http://www.cisco.com/go/sdm
- Smart Call Home: www.cisco.com/go/smartcall
- Web Services Management Agents (WSMA): http://tinyurl.com/wsma-in-150M
- Cisco Configuration Engine (CCE): www.cisco.com/go/ciscoce

- **Feature Navigator: www.cisco.com/go/fn**
- **MIB Locator: www.cisco.com/go/mibs**

Network Programming and Automation

Sustainable Innovation and Differentiation with Cisco Embedded Automation and onePK

Network Programming in a Cisco Open Networking Environment …

… provides Choice and Flexibility of

- APIs and Abstractions
- Architectures
- Deployment Models

… closes the gap between Business Applications and Networks

… enables Operational Savings and New Opportunities

… puts YOU in control

What will YOU Program ?

Prosíme, ohodnoťte tuto přednášku.

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