Virtual CPE Reality

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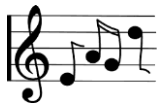
Orchestration: Etymology

Cynics opine that the only difference between
conventional networking and SDN/NFV-enabled networking
lies in replacing the word *management* with the word *orchestration*

To investigate this claim we need to ask *What is **orchestration*** ?

The term originates in music



- **orchestration** is the practice of writing/adapting music for an orchestra

Note: the person who conducts an orchestra is a conductor not an orchestrator

- **conducting** is the art of directing a musical performance, i.e.
  - setting the tempo
  - ensuring ensemble members enter and exit at the appropriate times
  - shaping *phrasing* according to policy

To conform with the time-honored musical convention

- the composing of scripts by a DevOps writer should be *orchestration*
- the running of a *management* system really should be *conducting*

Note: some web services chose yet another artistic analogy
and talk of *service choreography*

It all started with Data Center Orchestration ...

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So why do we use the term orchestration in SDN/NFV ?

The term was inherited from *data center operations*

In data centers orchestration denotes:

the automated management and coordination of computational resources, workflows and services

This task was originally carried out by sysadmins by *writing scripts*

and so was aptly named *orchestration*

With the advent of ubiquitous cloud services orchestration was redefined to:

deploying and monitoring of virtualized resources and management of highly dynamic workflows

But there is even more to the orchestration analogy ...

Physical Entities Are Typically Complex

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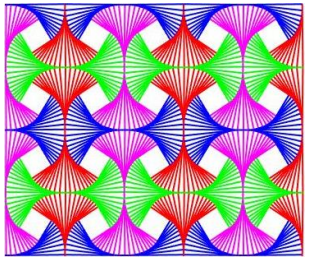
Physical systems are expensive and time-consuming to develop and to deploy
and are thus designed to be *multifunctional*



For example, a physical *router* may really include the following functionalities:

- Ethernet switch
- IPv4 unicast forwarder
- IPv4 multicast forwarder
- IPv4 intradomain control protocol peer
- NAT
- firewall
- DHCP server
- IPv6 unicast forwarder
- IPv6 multicast forwarder
- IPv4 interdomain control protocol peer
- tunneling endpoint
- IPsec gateway

and many more ...

Hence for networks based on such physical entities
management really means *configuration :*

- selecting desired functionalities from among the many available ones
- initializing each desired functionality

Reacting to events in the network is mostly handled by *control* protocols

Virtual Entities Can Afford To Be Atomic

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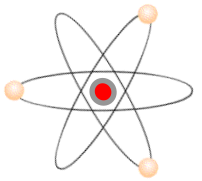

Virtual functions are inexpensive and fast to develop and deploy
hence we can afford to make them *atomic*
and build composite functions as needed by *service chaining*

In a *microservices* architecture

- services have fine granularity
- interconnection protocols are lightweight
- services are independently deployable

Atomic functions need to be

- dynamically placed at the proper place along the service path
- informed from whom to receive inputs and to whom to provide outputs
- informed as to (SLA related) policy considerations

but require very little other configuration

Hence for networks based on such virtual entities
orchestration means functional *selection*, *placement,* and *chaining*
but also *real-time reaction to network events*

Orchestration: Revisited

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So, we now have a deeper understanding for the word *orchestration*

A complex appliance is similar to an entire orchestra with its own conductor
while an atomic virtual function is like a single musical instrument

This is advantageous since the same violin can play many different scores, and

- play alongside 100 other instruments in a symphony orchestra
- play alongside 40 other instruments in a chamber orchestra
- play alongside 3 other instruments in a string quartet
- play alone in a solo performance

An orchestra *manager* deals with

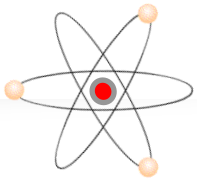
- financial aspects
- overall policy

but doesn't get involved in the functioning of individual musicians

An *orchestrator* has to

- intimately know each instrument and its relations to the others
- produce a score for each instrument
- give instructions to the conductor as to how to react in real-time

Ramifications of Atomicity



Functionality and APIs for atomic functions are simpler
and may be better adapted to service requirements

Functionality and APIs for atomic functions are more standardizable
this leads to more drop-in options and less vendor lock-in, and
expands the repertoire of service types using the same production process

New atomic functions combinations can be created on-the-fly
but only the compound function need be revealed to customers

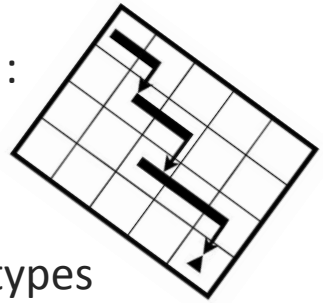
Atomic functions require fewer and less exotic resources
and can hence be more easily located (even in weak vCPEs) and relocated

There may be many more atomic functions to orchestrate
but the amplification is by a factor, not by an order of magnitude

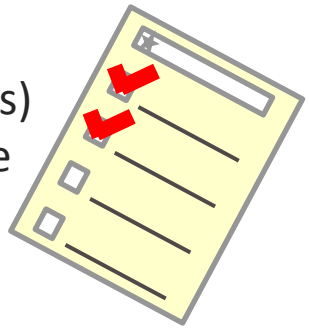
Faults and root cause identification can be centrally handled
based on standardized events from virtualized elements
rather than mostly up to internal logic of complex physical element

Operations for Conventional Networks

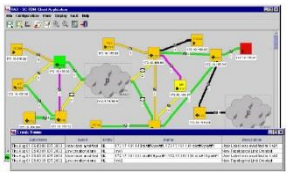
In the operations of networks based on physical appliances
configuration management is only one step out of many :



- **long term planning** (BSS)
  - based on customer relationships and technological advances
  - predict needed hardware resources from many link/equipment types
  - purchasing, directing layout of physical resources



- **service planning** (OSS)
  - based on customer requests and legal constraints (e.g., SLAs)
  - determine how to most efficiently provide promised service

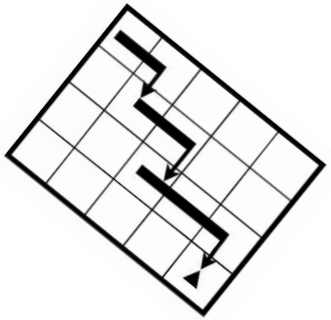


- **management** (NMS)
  - configuration and commissioning testing
- **control** (protocols)
  - monitoring and reporting
  - reacting to events

Operations for Orchestrated Networks

There are fewer steps in operations for networks employing virtual entities

- **long term planning** (BSS)
  - measure and collect trend information
  - acquire three types of hardware resources
    1. links (physical (fiber) or virtual (lambda))
    2. switches (physical (appliances) or virtual (vSwitches))
    3. computational (physical (CPU) or virtual (VM))
  - acquire pools of software licenses



- **orchestration and control**

Note that short term planning has disappeared
as it is carried out *automagically* by the orchestration system
For example – actual software images may be retrieved automatically

It is interesting that SDN uses the term *control*
in an attempt to emphasize its speed and dynamic nature
On the other hand NFV uses the word *management*
because it was more comfortable for service providers

vCPE vs. Cloud-based NFV

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We already mentioned that NFV and orchestration facilitates function *relocation*

In fact, NFV can not simply mean making appliances out of software -
network appliances have been software-intensive for years!

NFV actually means:

1. running network functionality on generic COTS whitebox servers
2. breaking down network functions into atomic functions
3. placement
4. chaining these functions together
5. optimizing and managing the computational and network infrastructures

The first point is the definition of NFV, and we have discussed 2, 3, and 4

Cloud-based NFV satisfies 1-3 by replacing hardware with generic software
but doesn't optimize the computational or network infrastructure

The option to relocate VNFs to the (v)CPE fundamentally changes the network
both in deploying functionalities in new places
and potentially redirecting traffic in new ways (e.g., SD-WAN)

Why vCPE ? (1)

Why is the vCPE concept attractive to service providers?

The originally envisioned advantage of NFV was performance scaling
in order to maintain profitability margins

vCPE platforms do *not* offer any CAPEX pricing advantage
since typically CPE devices are already engineered for cost reduction
In fact, generic software implementations are generally less efficient
making it challenging even to meet appliance costs

The advantage in vCPE is agility in function and service creation

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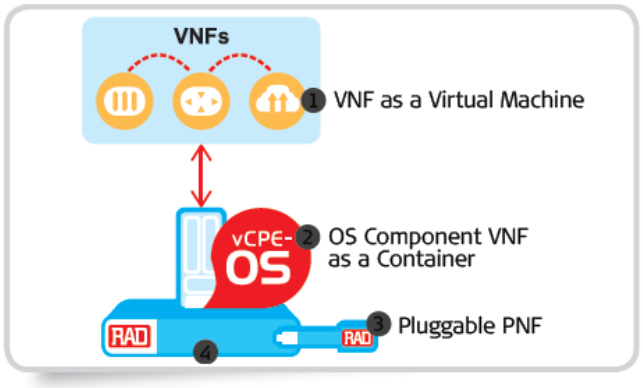
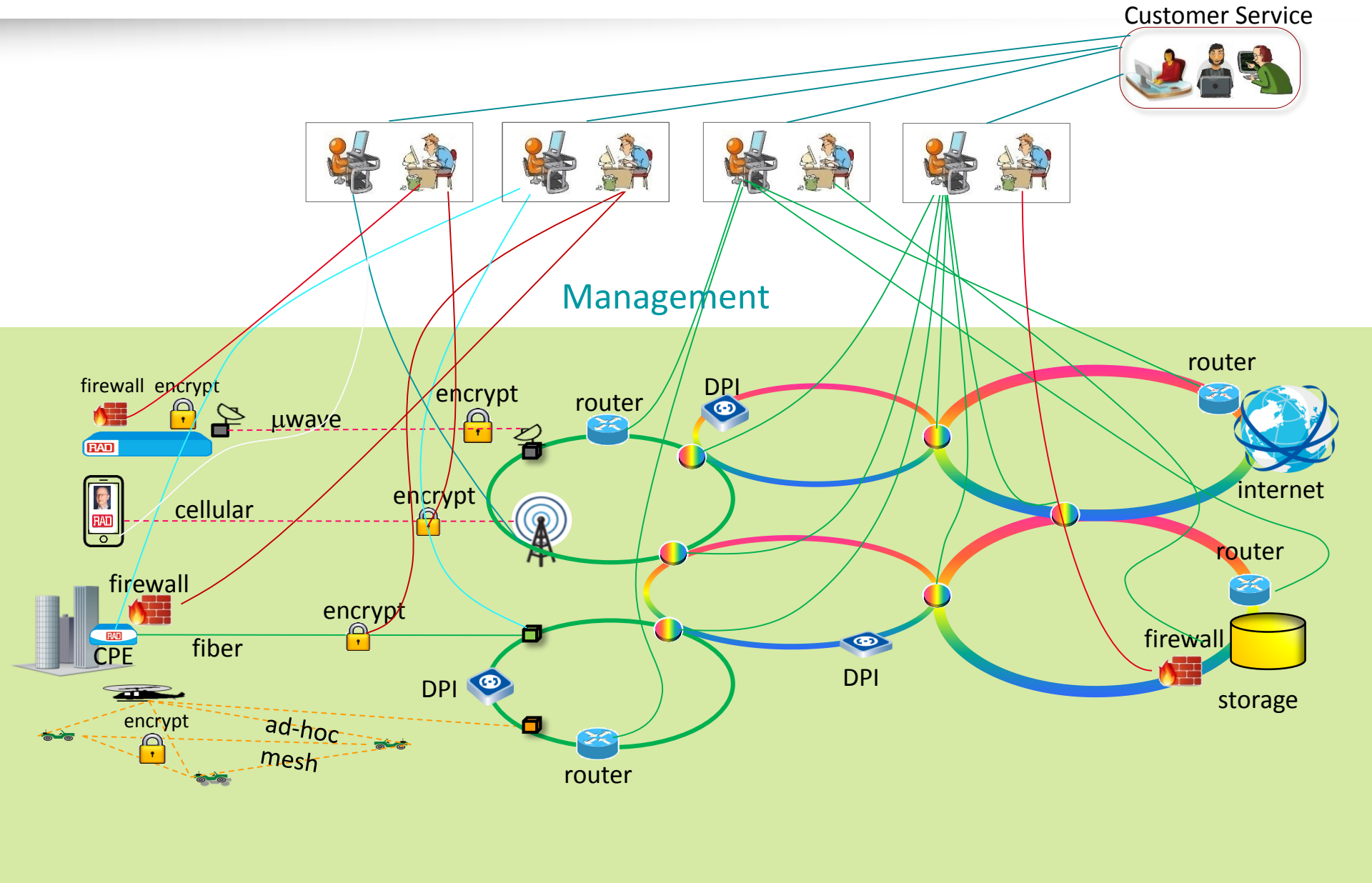


Why vCPE ? (2)

This agility results in:

- reduced time to develop attractive new services
  - e.g., SD-WAN services (a prime application of vCPE)
- reduced time to revenue and offering of **M**inimal **V**iable **P**roducts
- enhanced user experience
  - try & buy
  - quick turn-up, etc.
  - user charged for functionality only when needed
- ability to support two VPN types in a single platform
  1. IP (traffic can go through DC/HQ)
  2. CE (ELINE)
- ability to support two fundamentally types of VNFs
  1. customer visible **V**alue **A**dded **S**ervices (beyond basic connectivity)
  2. operational (only visible to the service provider)
- from networking to IT premium services
  - *computications* enabler (as discussed last year)

From Management to Orchestration



From Management to Orchestration

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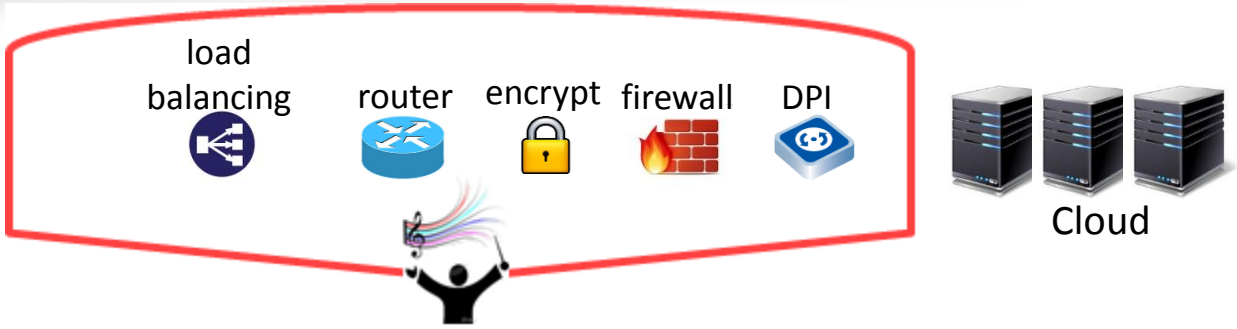
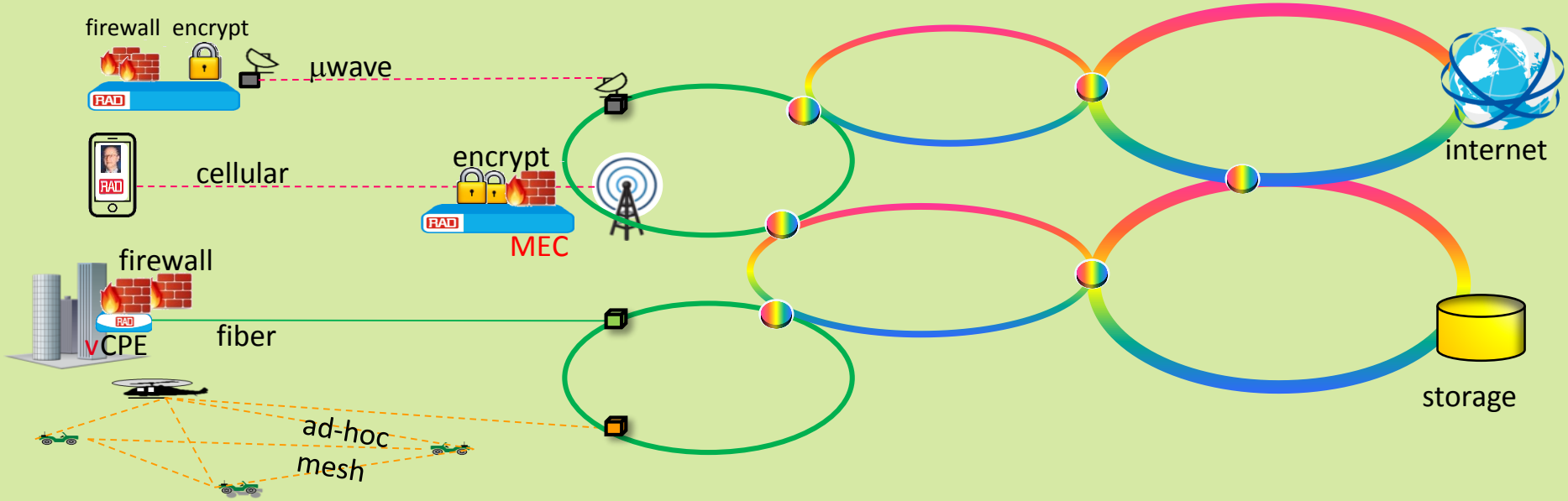


Orchestration



Thank you for your attention

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