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# *Refactoring Future Residential Networks into Slices*

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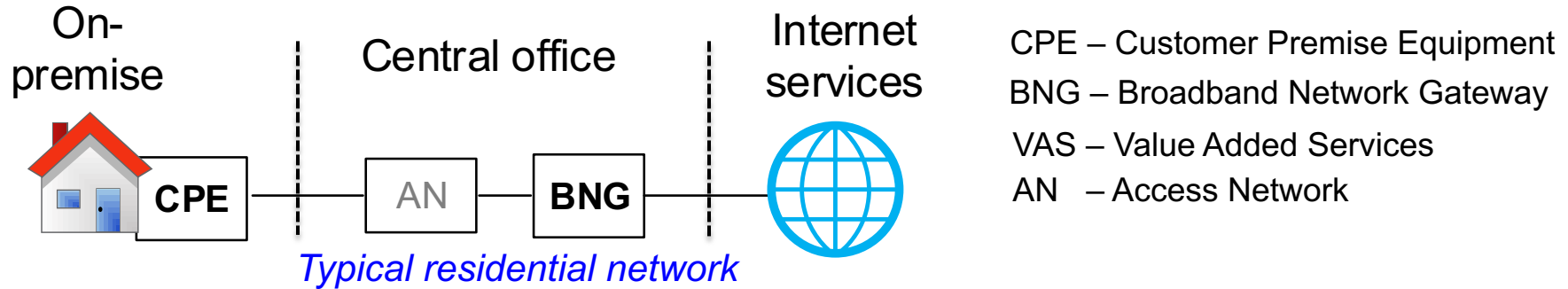


# *Outline*

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- Introduction
- Goal and Challenges
- Residential Slice Scenarios
- Proposed Refactoring
- Implementation
- Conclusion

# Introduction



## ■ Residential broadband networks

Users	408M (fixed-line) in 35 nations (Dec.'17*)
Revenue	25~30% contribution (AT&T, and Verizon)
Standardization	Broadband Forum (BBF)
VAS	Mobile TV, AV-over-IP, Video-on-Demand, etc.

## ■ 5G residential network vision

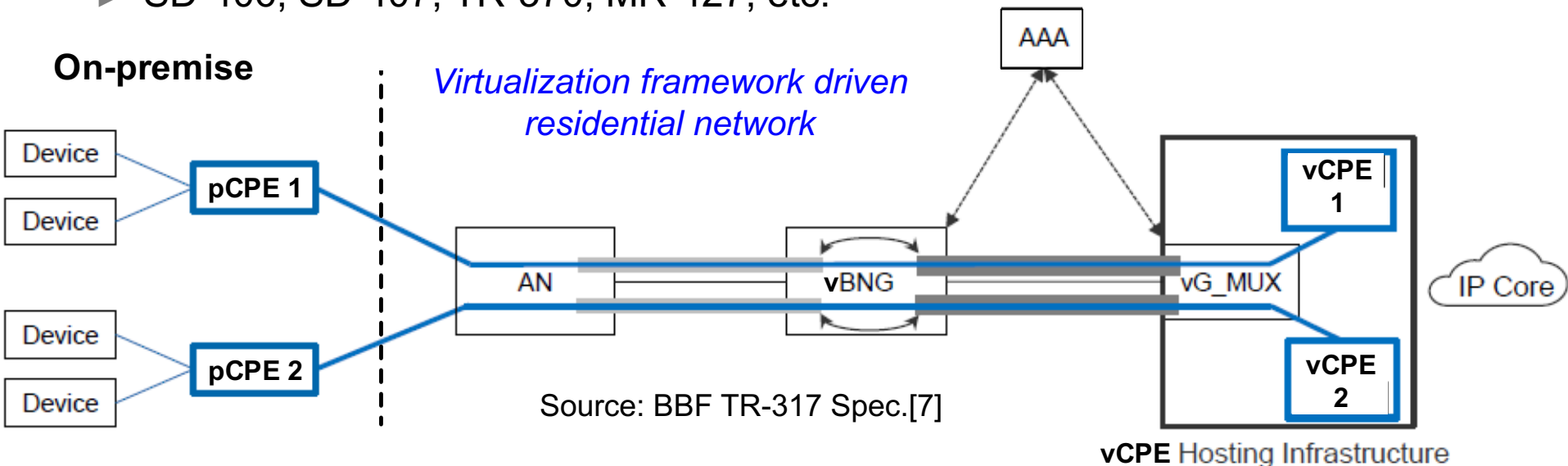
- ▶ Migrate to “network per service” from “one-size-fits-all”

\*<https://www.oecd.org/internet/broadband/broadband-statistics-update.htm>

# Current Landscape of Network Slicing

- One of the fundamental 5G enablers [5]
- Cellular networks already adopted
  - ▶ 3GPP TS 23.501, 23.502
  - ▶ 3GPP SA5 + BBF (TS 28.530, 28.531)
- One of the key study areas in BBF
  - ▶ SD-406, SD-407, TR-370, MR-427, etc.

BBF – Broadband Forum  
 AN – Access Network  
 vG – Virtual Gateway  
 vG-MUX – vG-Multiplexer



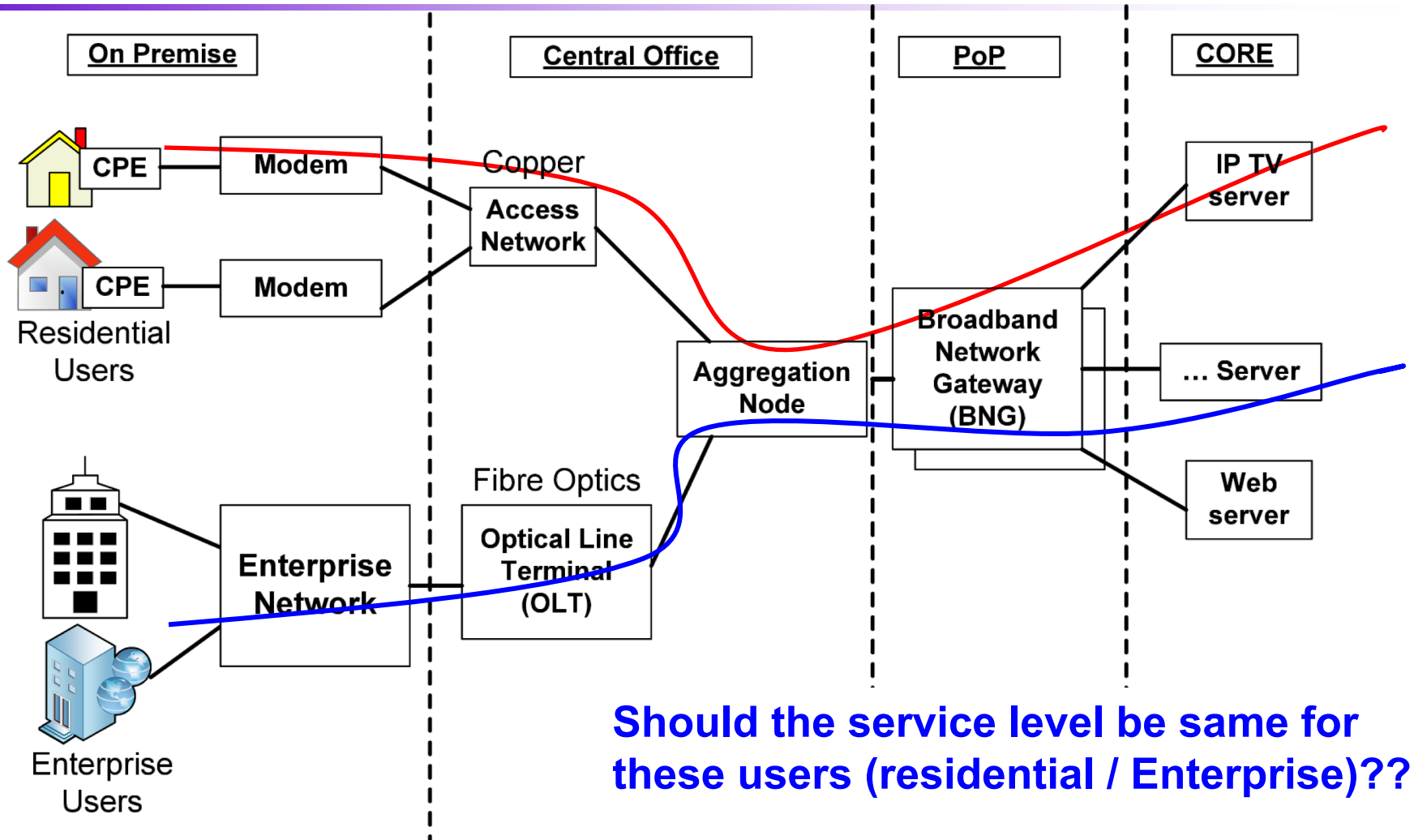
# *Goal and Motivation/Challenges*

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- Goal of this paper
  - ▶ Refactoring BBF network elements to enable slicing<sup>†</sup>
  
- Challenges in current residential network to become 5G ready
  - ▶ Network slicing is still under study in BBF [3]
  - ▶ Slicing criteria tradeoff
    - ★ Per user based, traffic class based, service based, etc.
  - ▶ Scattered BBF network elements
    - ★ Realize slice admission control and selection
  - ▶ Complex network management
    - ★ Separation of concerns (Service orchestration and NFV orchestration)

<sup>†</sup>Access network slicing is out of scope

# Residential slice scenario #1 (1/2)



**Should the service level be same for these users (residential / Enterprise)??**

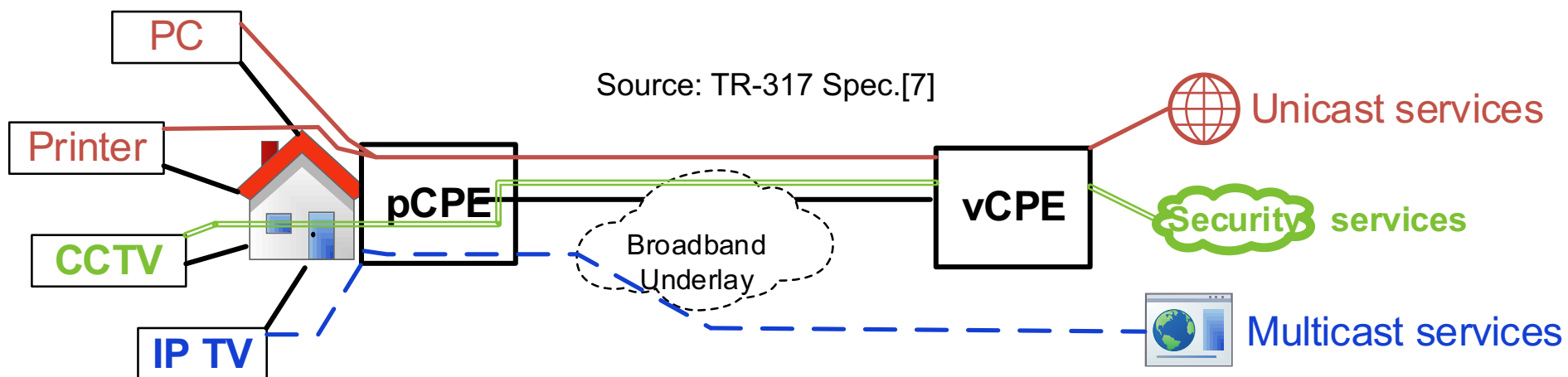
CPE – Customer Premise Equip.

PoP – Point of Presence

# Residential slice scenario #2 (2/2)

## ■ Examples of per-device specific services

- ▶ Parental control, guest services restriction, etc.
- ▶ Enhanced home office, assured multimedia, etc. (priority based)



**Should all devices be served by a vCPE?  
Same vCPE??**

# ***What are we addressing?***

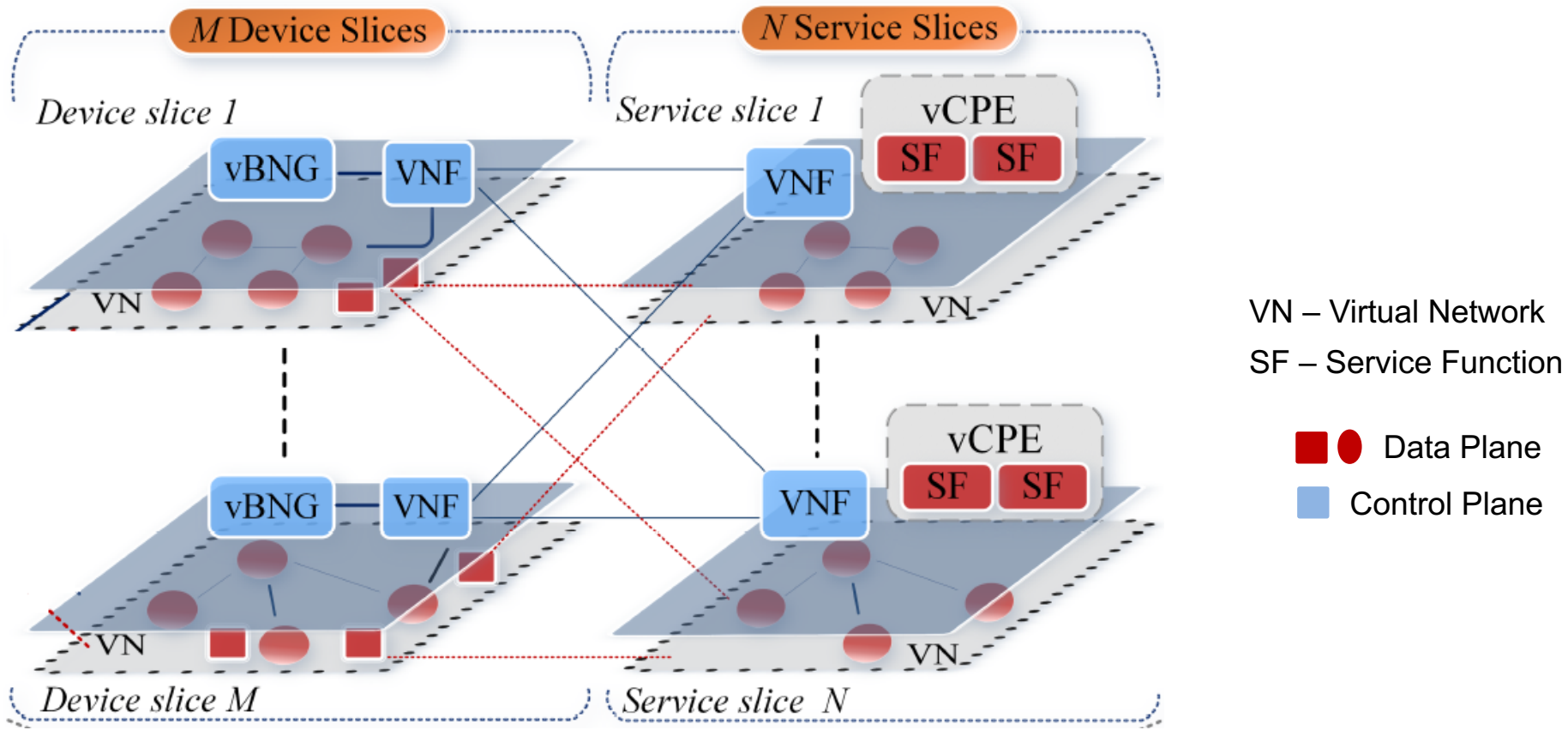
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- Slicing criteria
  - ▶ What is the basis for grouping to form a slice?
  
- Slice admission control
  - ▶ What refactoring is required to enable slice selection?
  
- Orchestration abstraction
  - ▶ How to simplify service discovery and orchestration?



# Proposed Basis for Grouping

- Classifying slices based on **device-type** and **service type**



vBNG – Virtual Broadband Network Gateway

vCPE – Virtual Customer Premise Equipment

# Proposed Refactoring

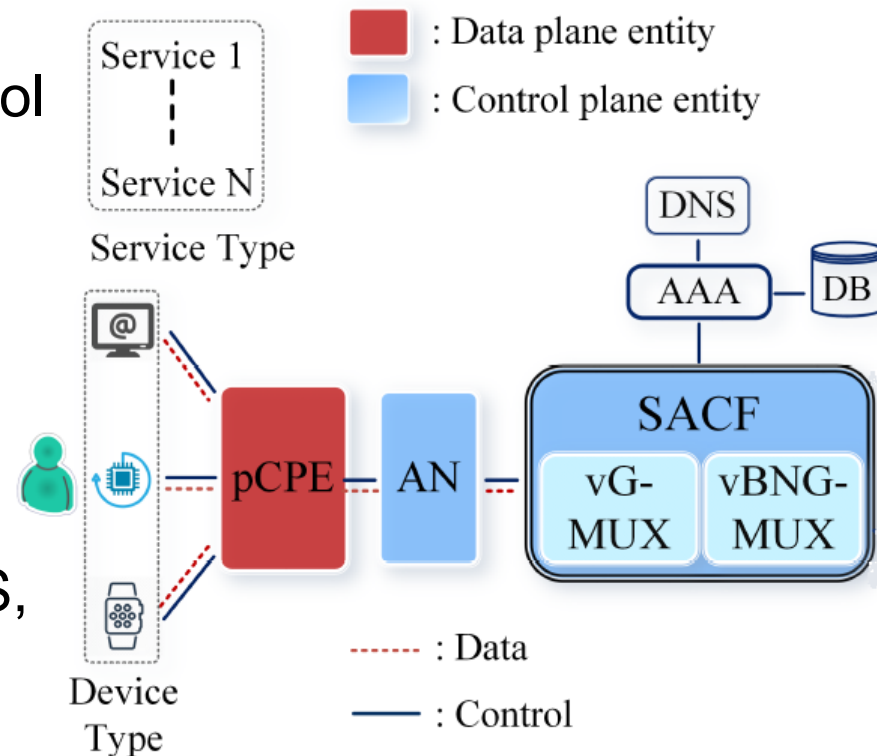
■ Refactoring BBF network elements for slice selection

■ Proposed Slice Admission Control Function (SACF)

▶ vBNG-Multiplexer (vBNG-MUX)

▶ vG-Multiplexer (vG-MUX)

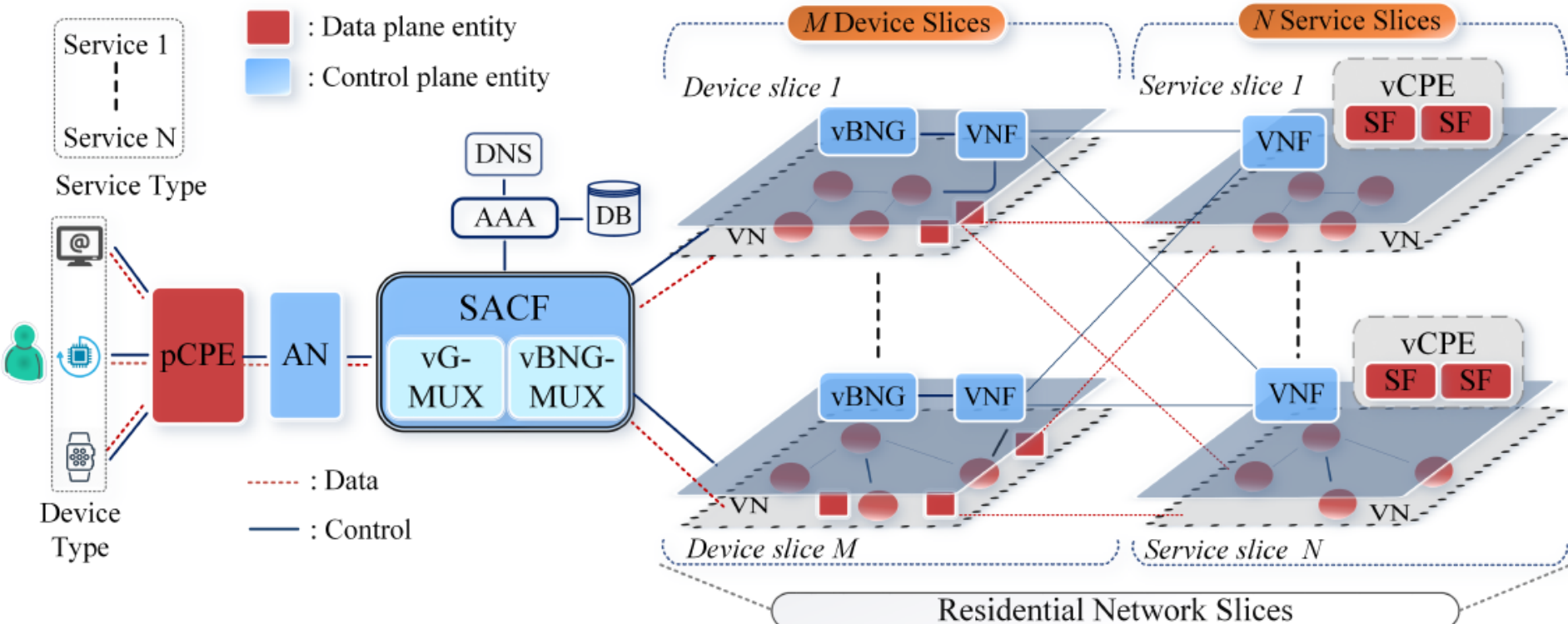
■ Communication between AAA, DNS, DB as per TR-317 and TR-345



# Proposed Refactoring

## Overall restructuring

Overall refactoring of BBF network elements to support slicing and slice admission control



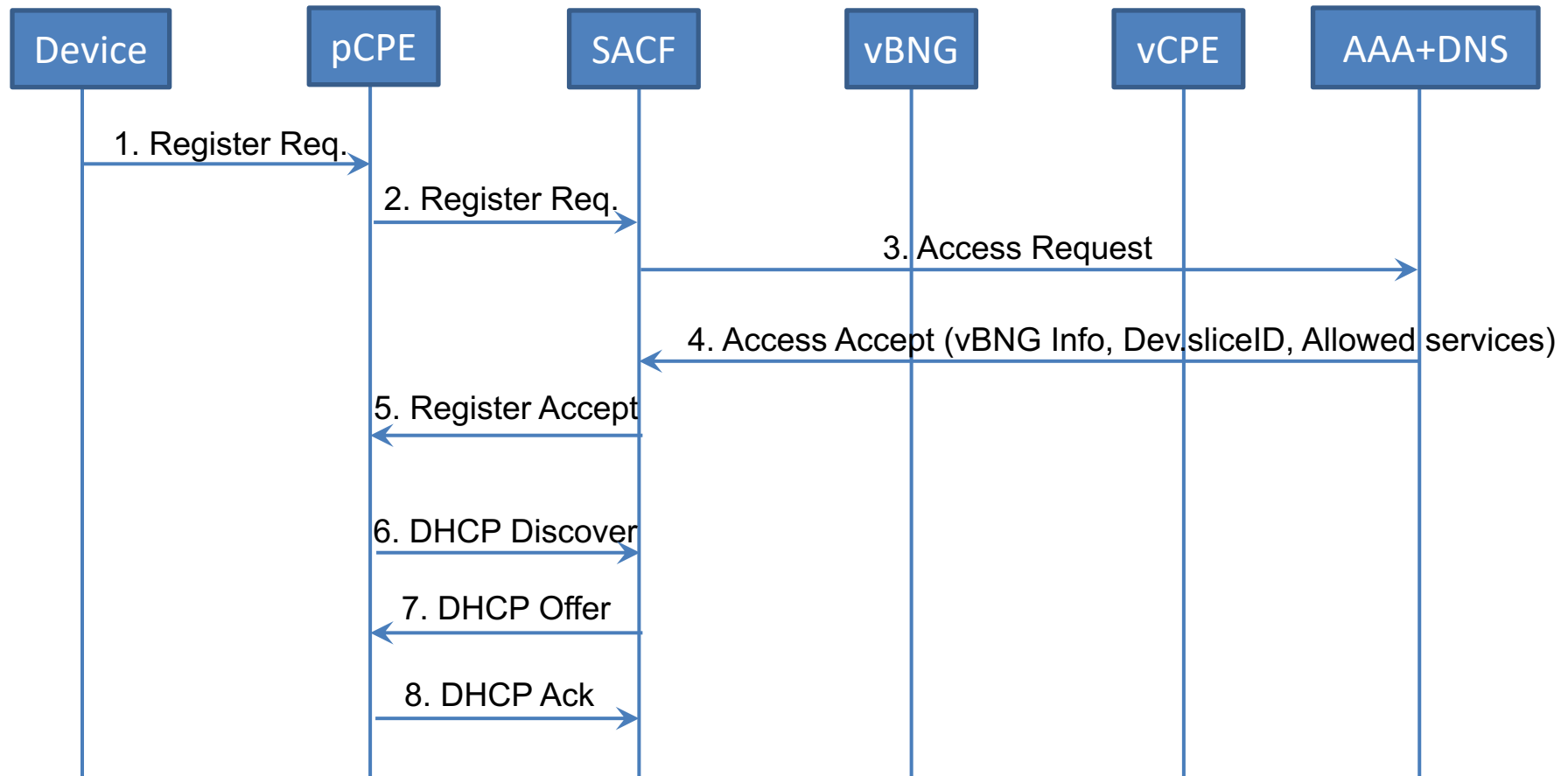
**Legend:**

- AN : Access Network
- VN : Virtual Network
- p/vCPE : Physical/Virtual Customer Premise Equipment

- vG-MUX : Virtual Gateway - Multiplexer
- vBNG-MUX : Virtual Broadband Network Gateway - Multiplexer

# Proposed Refactoring

## Device registration to a slice



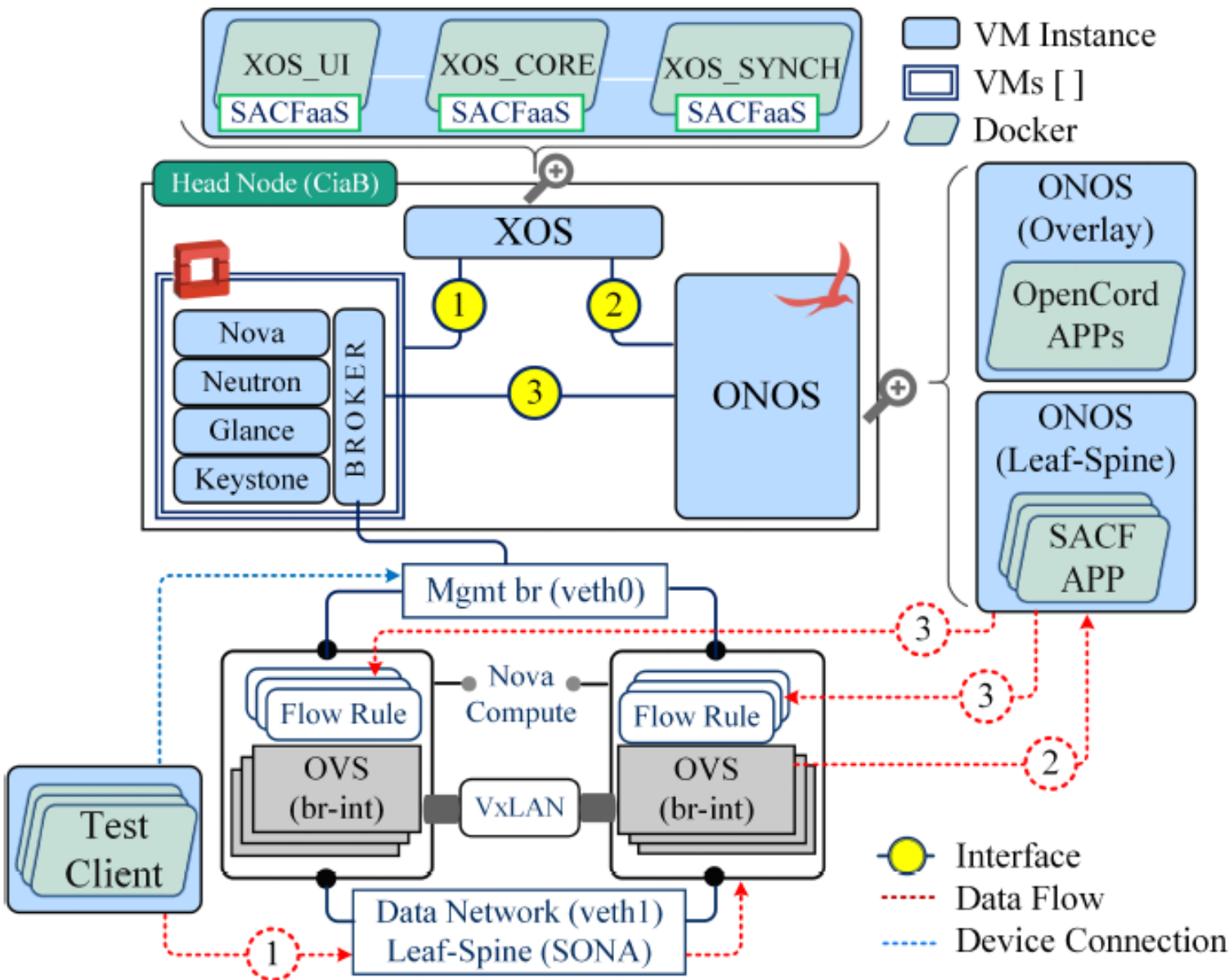
Signaling to enable device registered to a slice

# *Proposed Refactored Orchestration*

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- Service orchestration as thin abstraction layer
  - ▶ Service discovery
  - ▶ Subscriber aware listing of services
  - ▶ On-premise/off-premise service function determination
  - ▶ Creation, assignment and management of service-IDs based on service-type + device-type

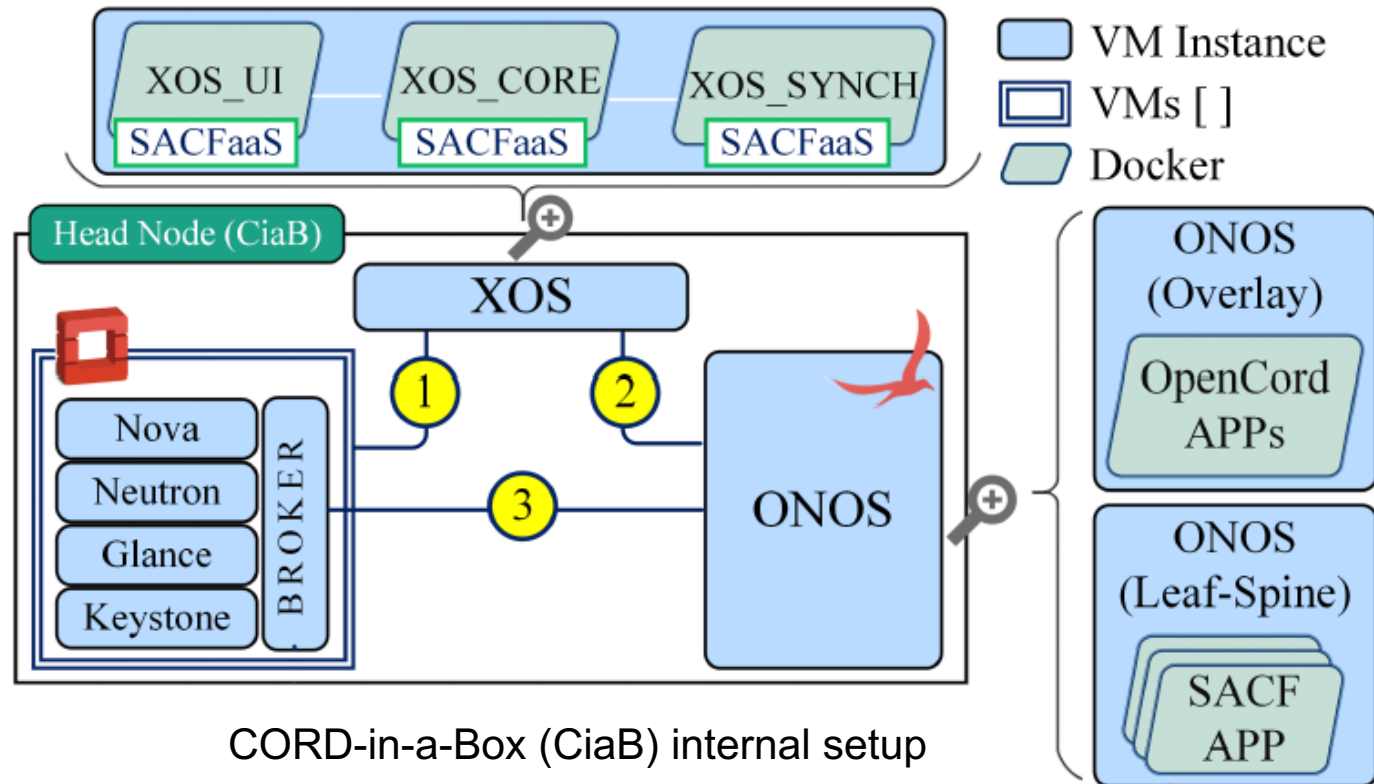
# CORD



(a) CiaB internals with XOS and ONOS components of SACF function, showing high-level data flow from TestClient to ONOS controller.

# Implementation on CORD

- Central Office Rearchitected as Datacenter (CORD)
- CORD-in-a-Box (CiaB) is Single server emulator having
  - ▶ XOS (Orchestrator)
  - ▶ ONOS (SDNC)
  - ▶ OpenStack

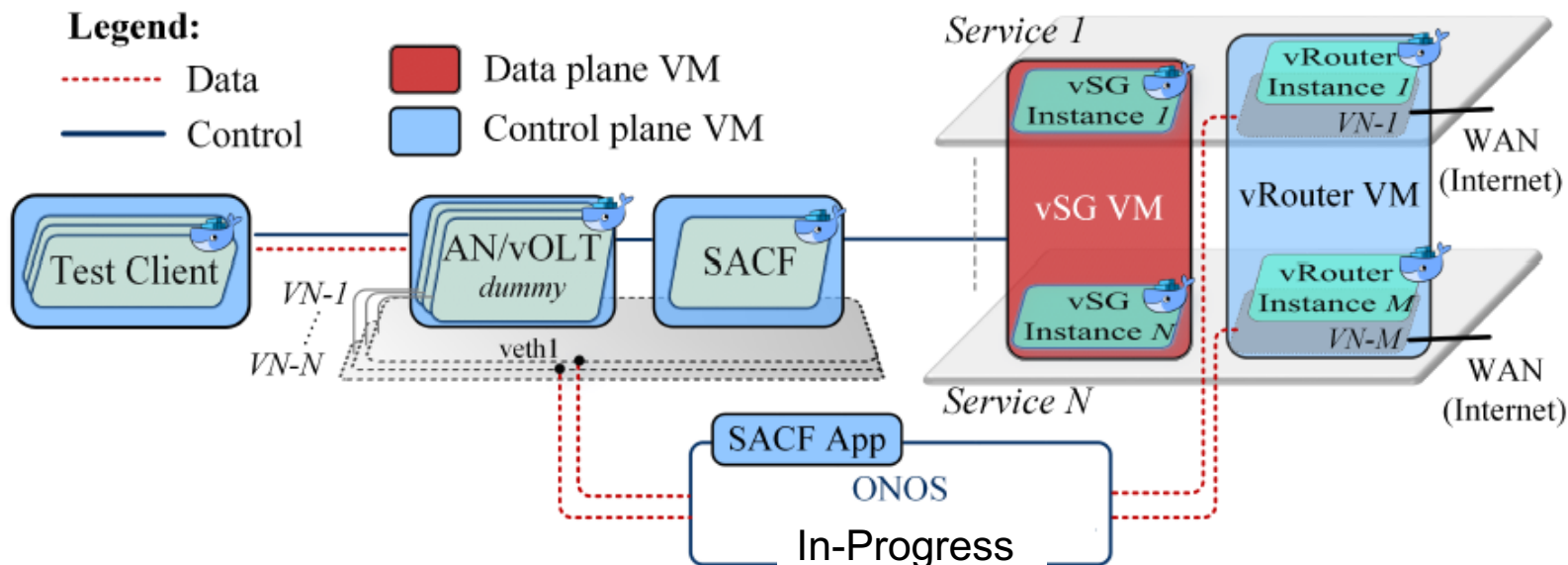


# Implementation

## ■ Slice Admission Control Function (SACF) prototype implementation

- ▶ Two test clients representing different devices
- ▶ Service type differentiated based on IP:Port (1007 and 1010)
- ▶ Device profiles assumed to be present (JSON config. File)

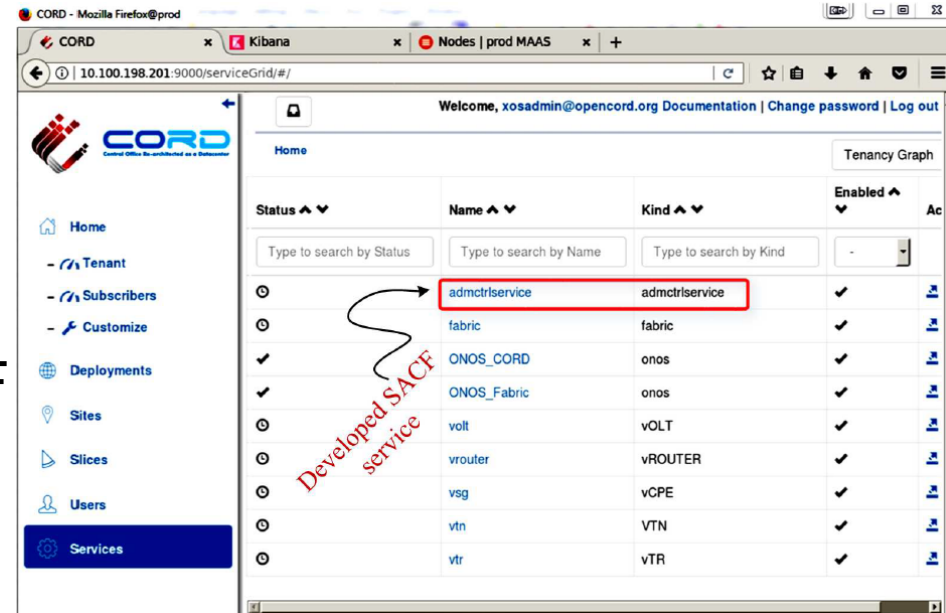
Prototype Server Graph of SACF





# Current Results

- Successful interfacing of SACF microservice in the existing CORD service graph
- Connection request is properly received by vBNG through SACF service and is successfully responded
- Successful management plane connectivity, governed by ONOS overlay instance and XOS
- On-going dev. of SACF-APP control app. on ONOS to assign device and service flows to respective slices



The screenshot shows the CORD service grid interface. The table lists various services with their status, names, kinds, and enabled states. The 'admctr/service' entry is highlighted with a red box, and a red arrow points to it from the text 'Developed SACF service'.

Status	Name	Kind	Enabled	Ac
⊙	admctr/service	admctr/service	✓	ⓘ
⊙	fabric	fabric	✓	ⓘ
✓	ONOS_CORD	onos	✓	ⓘ
✓	ONOS_Fabric	onos	✓	ⓘ
⊙	volt	vOLT	✓	ⓘ
⊙	vrouter	vROUTER	✓	ⓘ
⊙	vsg	vCPE	✓	ⓘ
⊙	vtn	VTN	✓	ⓘ
⊙	vtr	VTR	✓	ⓘ

# ***Conclusion***

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- Network slicing will make its way in BBF driven residential networks sooner or later
  
- We proposed
  - ▶ Device and service slices managed by dedicated vBNG and vCPE
  - ▶ Network slice admission control function
  - ▶ Decomposition/reorganization of latest BBF elements
  
- On-going implementation on CORD to evaluate the proposed SACF