Merging NFV with SDN

break the boundaries between the two domains!

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The two domains

SDN and NFV are two separate domains, one useful to the other but with a clear separation between them.

- SDN: traffic steering, packet switching, function chaining…
- NFV: agile Network Function allocation, easy to allocate new functions….

Can we try to merge them? Find ways to jointly orchestrate the two domains?

Limitations in NFV

- Scalability to hundreds of Gbps (difficult with general purpose HW)
- NFV is increasing its computation requirements
- Network functions have common patterns not currently exploited

Limitations in SDN

- It is used mainly for traffic steering
- Lots of capabilities
  - OpenFlow
  - Data plane programmability (P4 - Tofino)
  - Stateful data plane (OpenState, OPP, “Domino-Banzai”)
  - SmartNIC
  - “Networked” FPGA (NetFPGA)
- Controller is used only as an interface between Applications and Network

IDEA: Break the boundaries!

We want to propose a ***framework*** to merge NFV and SDN

It will allow to:

- ***offload computation*** from NFV to SDN in an easy way
- program **easily** and **jointly *network and functions***
- **optimize *how*** and ***where*** the functions are placed

Network functions offloading

- Already a lot of examples (e.g. DPI offloading, iptables offloading, checksum offloading...)
- No commonalities that can be exploited for other works
- Offloading usually built as a *specific implementation*

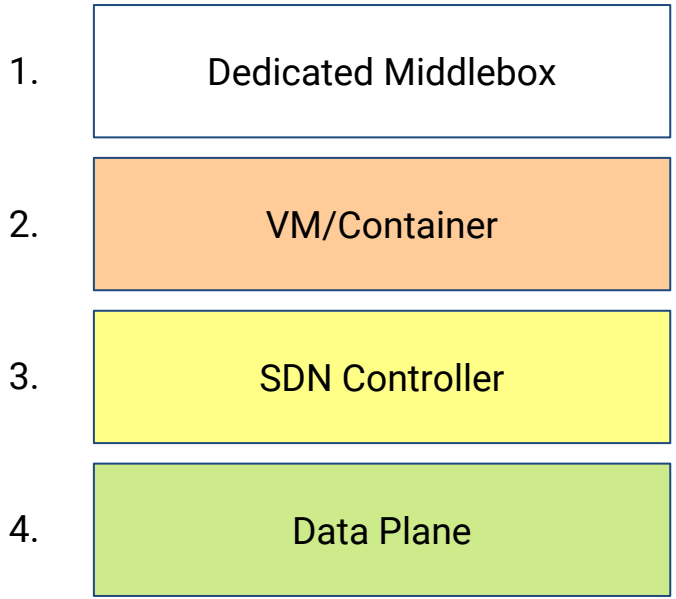
→ We can identify different “offloading layer”

→ We can divide network function to exploit commonalities

Different offloading layers of Network Function

Network functions can be allocated on different offloading layers depending on:

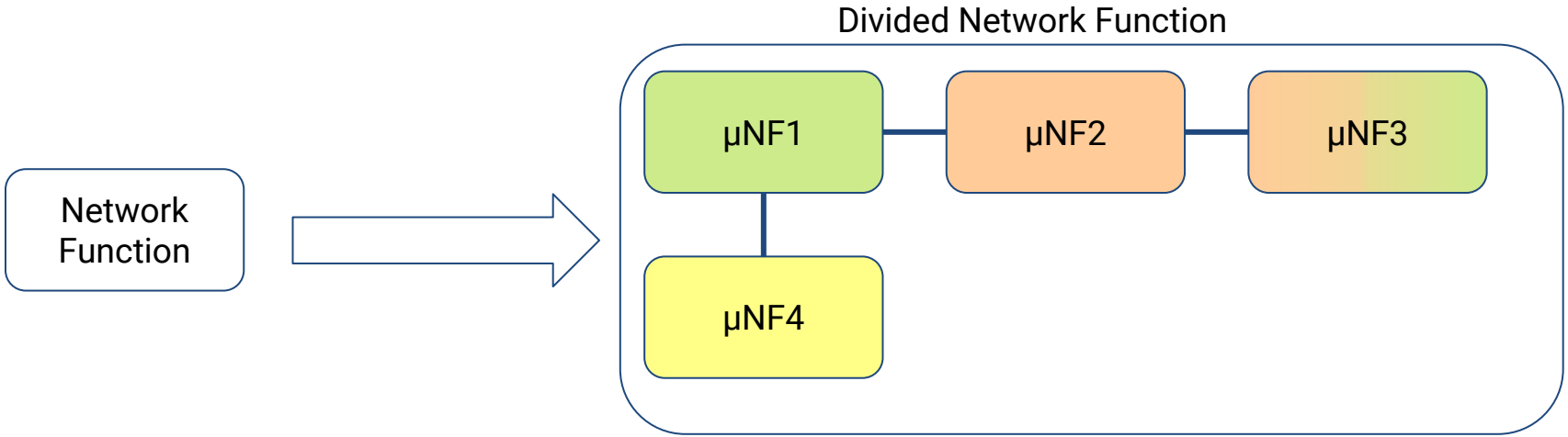
- network capabilities
- function requirements



Divide network functions

NFs can be divided in smaller functions that can be exploited by other NFs

We want to introduce the concept of **reusability** of network functions.



Network Micro-Functions Library

- Matching (header/payload)
- Actions (drop, output….)
- Filtering
- Metering
- Replication
- Aggregation
- Small computation (header/payload) (e.g. checksum verification, sum….)
- Load balancing (splitting)
- Classification
- Shaping/Throttling
- Encryption
- Feature extraction
- Traffic generation
- Inter-flow/intra-flow conditions
- *End system protocols (e.g. TCP or upper layers)*

Network as a set of multipurpose devices

Each network device has some ***computation capabilities*** other than simple network related functions (e.g. packet switching, traffic steering).

We can map the previously identified μ**-Functions** in the network devices

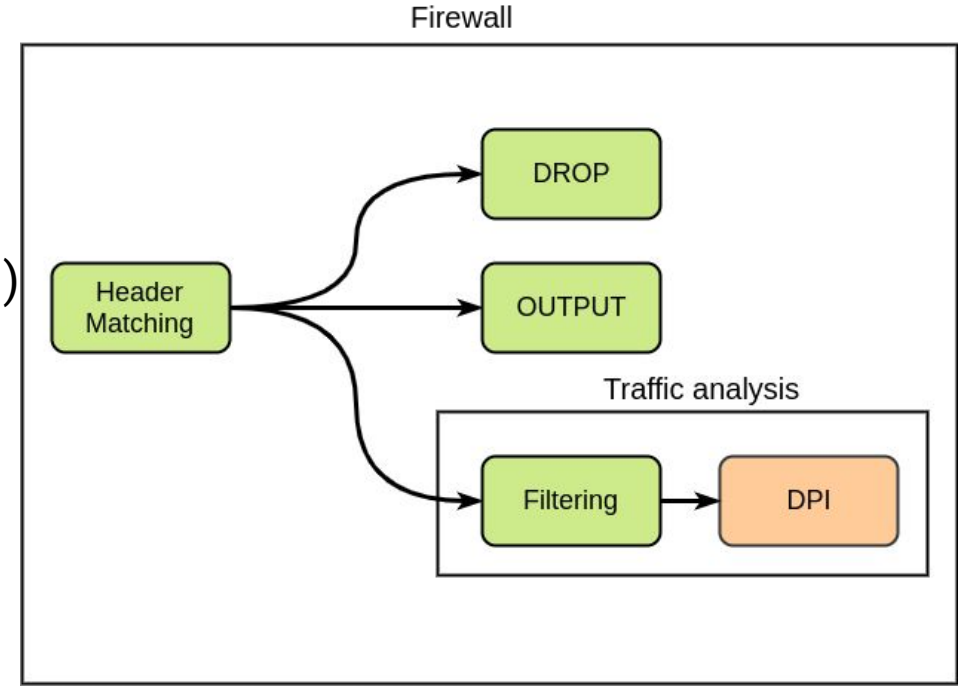
We can create a ***unified view*** of capabilities of network devices

Example - Firewall

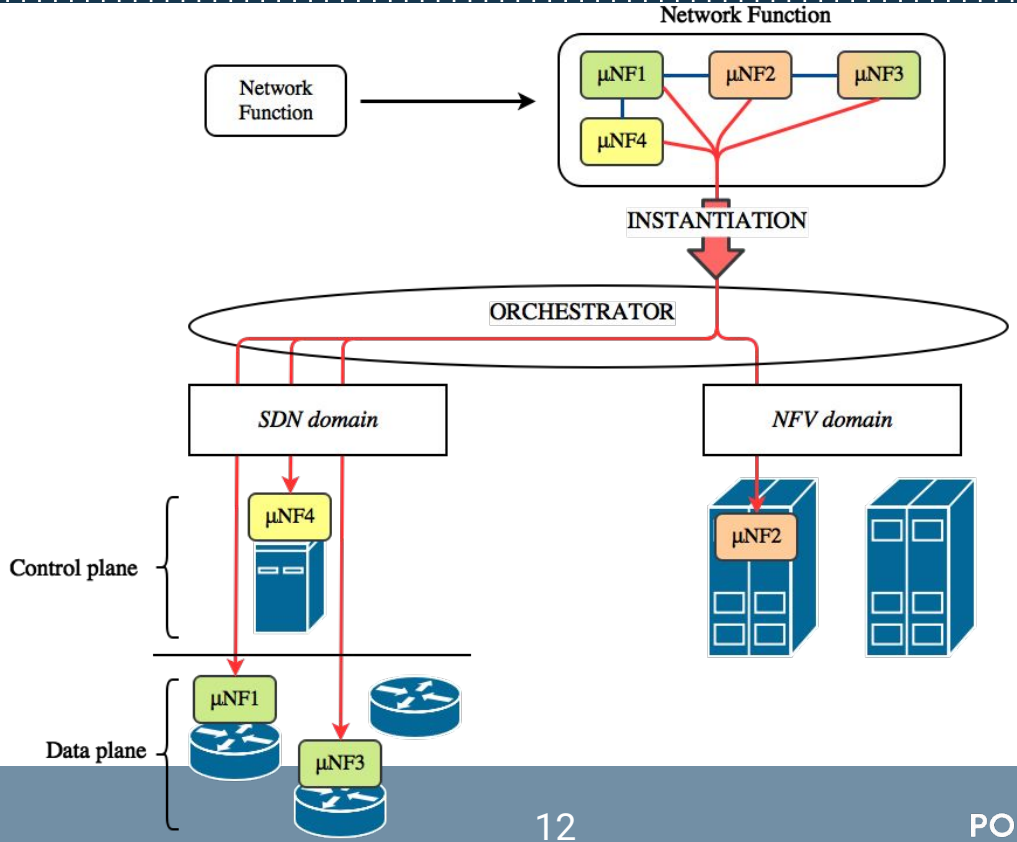
A simple firewall can be divided into:

- Header matching
- Action (Drop/Output)
- Traffic analysis (further separation)
  - Filtering
  - Classification

- Header matching, actions and filtering can be implemented in the data plane
- Classification can be implemented as DPI in a VM



Example


Network Function
Network Function
µNF1
µNF2
µNF3
µNF4
INSTANTIATION
ORCHESTRATOR
SDN domain
NFV domain
µNF4
µNF2
Control plane
µNF1
µNF3
Data plane

Starting points (Framework)

- Network Programming Language: *Merlin (extension)*
- SDN Controller: *ONOS*
- Programmable (Stateful) Data Plane: *OPP/OpenState/P4*

What we need (for the Framework)

- ***Offloading*** use cases!
- Identify ***commonalities*** between network functions (identify more micro-functions)
- ***Divide*** network functions into micro functions
- ***Language*** to define how network and functions can cooperate
- ***Compiler***, multiple optimization models with different objectives:
  - network capabilities
  - network requirements (limitations in terms of bandwidth, latency, servers...)
- ***Instantiation process*** that translates high level language to low level network implementation (merge language with optimization models)

Compiler

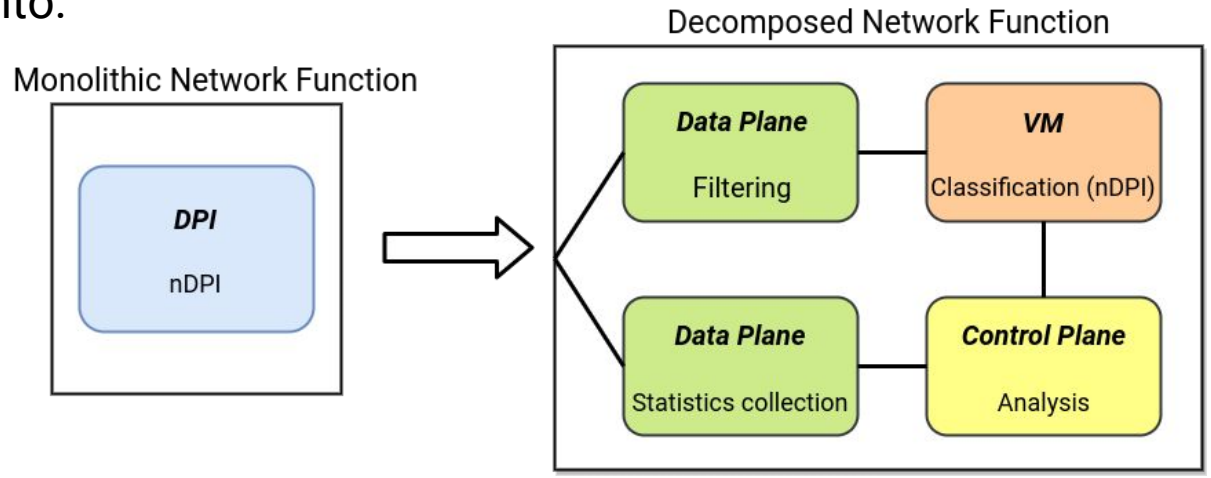
Defined as multiple optimization models with different objectives

- ***Network Capabilities:***
  - available offloading layers
  - layers capabilities
  - devices capabilities
  - network topology
- ***Network Requirements:***
  - bandwidth
  - latency
  - max number of instantiatable VMs
  - ...

Offloading example: DPI offloading to stateful data plane

Monolithic DPI NF divided into:

- filtering
- statistics collection
- classification
  (less traffic to analyze)
- analysis



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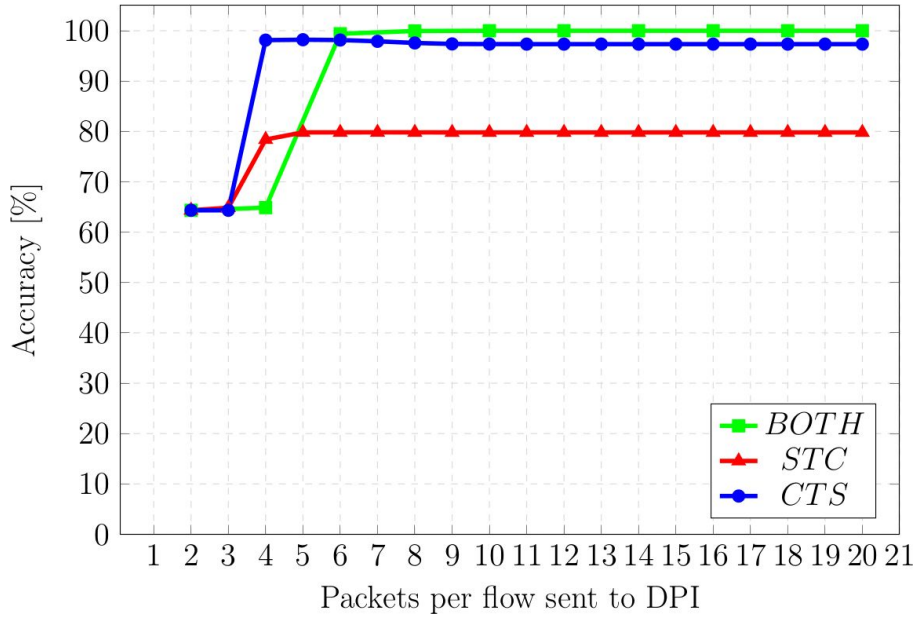
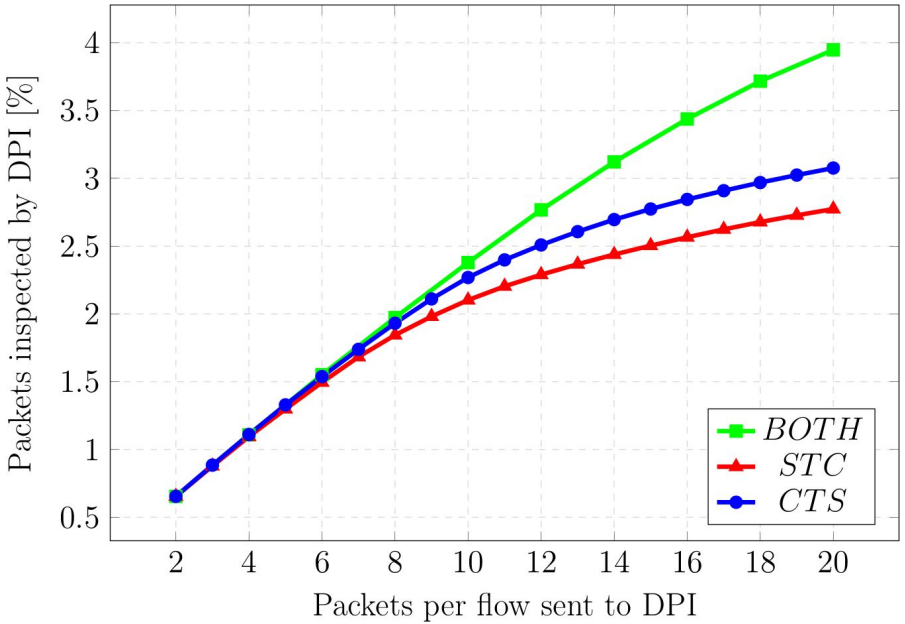
"Towards traffic classification offloading to stateful SDN data planes" , 2017 IEEE Conference on Network Softwarization (NetSoft)

Some results





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Conclusion

Offloading to SDN is an hot topic.

No one has developed a common framework to work with.

Short term objectives:

- More offloading use cases
- Identify commonalities between network functions
- Define optimization models with different trade-off between constraints and network capabilities to offload NFs

Long term objectives:

- Define a language to merge both high and low level functionalities
- Compile the language with different network objectives and capabilities
- General framework for the compilation process

Micro function for edge computing

The framework and an extended library of micro-functions can be provided by network operators to developers for building application at the edge of the network.

Micro-functions as base functions for **Edge Computing**

The framework can be an *enabler* for Edge Computing

Help us!

Early stage research work!

Feedbacks, **suggestions** and also **critiques** will be really helpful

If someone is interested in a **collaboration**, let us know!!!

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