

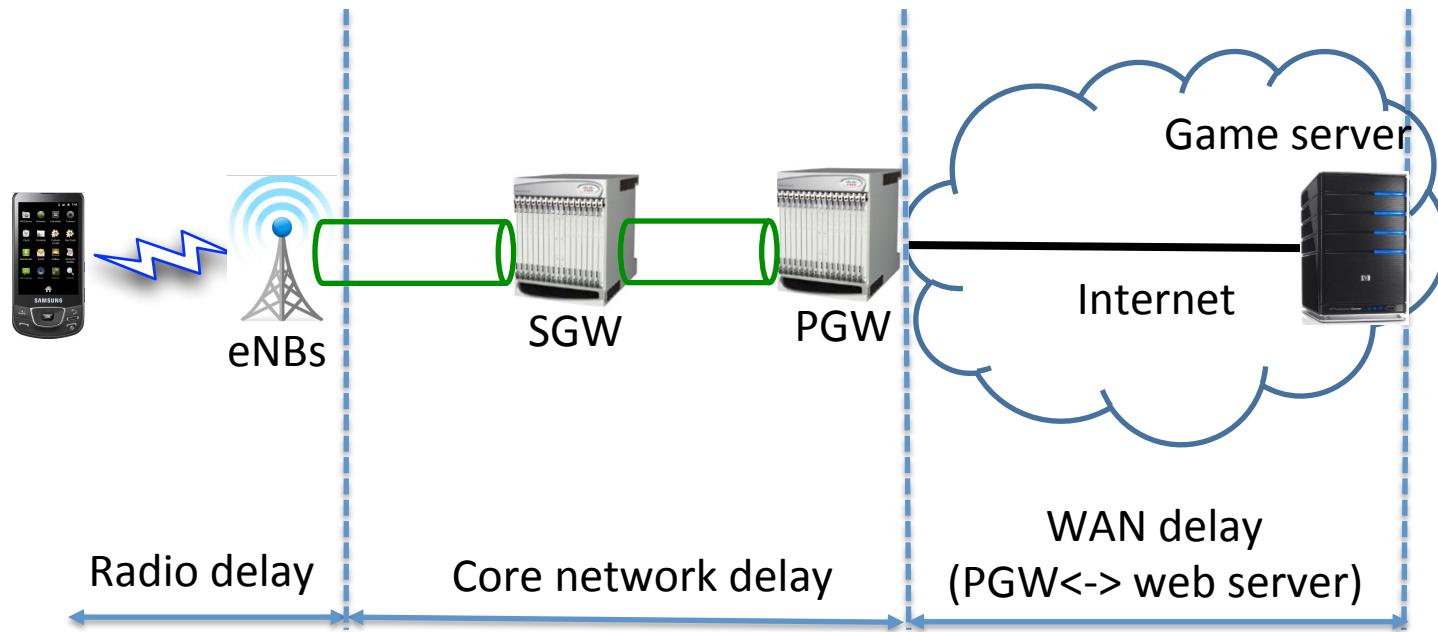


SMORE : Software-Defined Networking Mobile Offloading Architecture

Junguk Cho, Binh Nguyen, Arijit Banerjee,
Robert Ricci, Jacobus Van der Merwe, and Kirk Webb

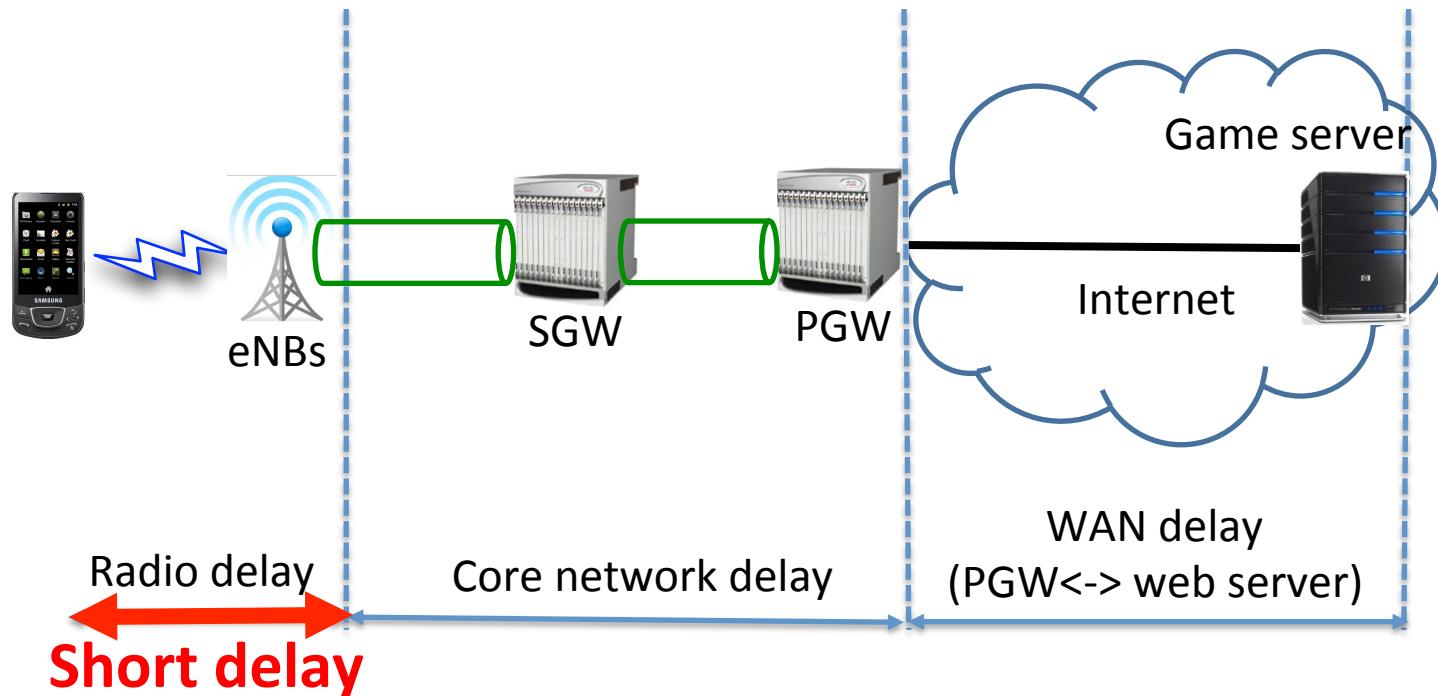
Motivation

Mobile Network



Motivation

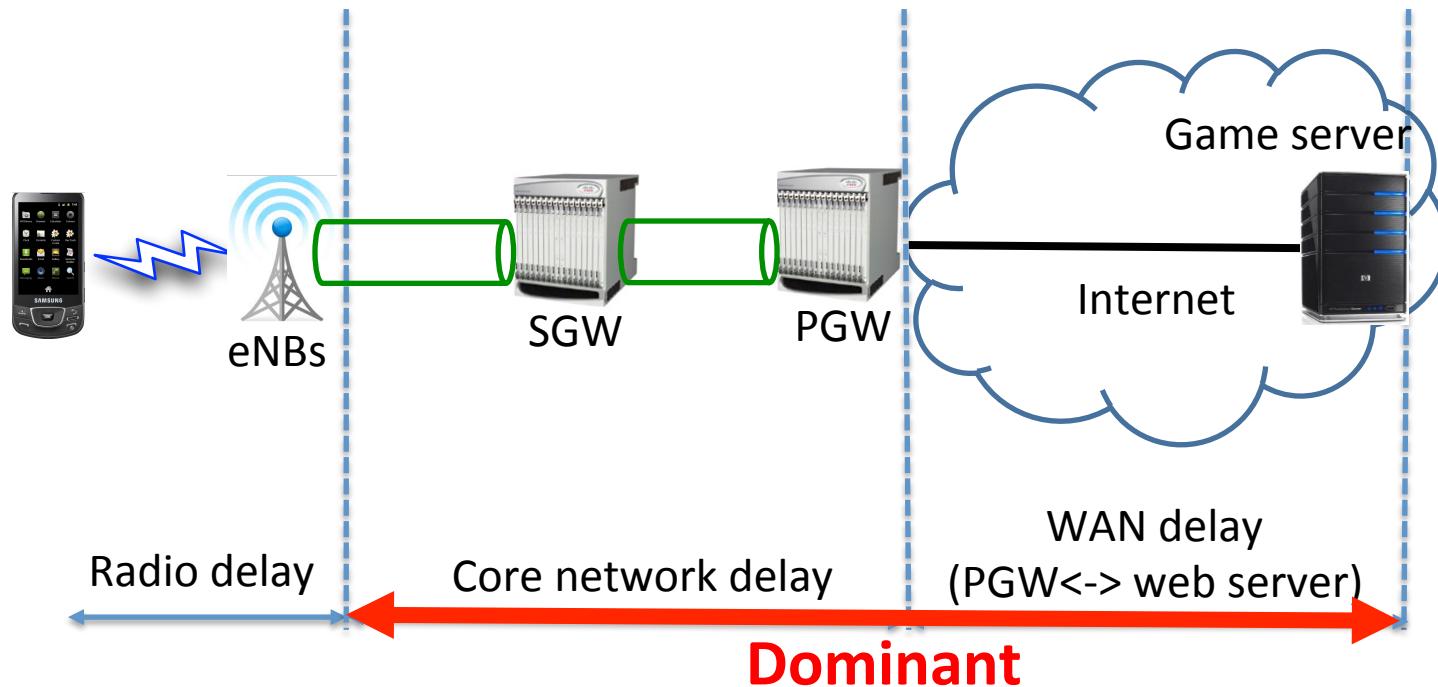
LTE/EPC Mobile Network



3G → 4G^{LTE}

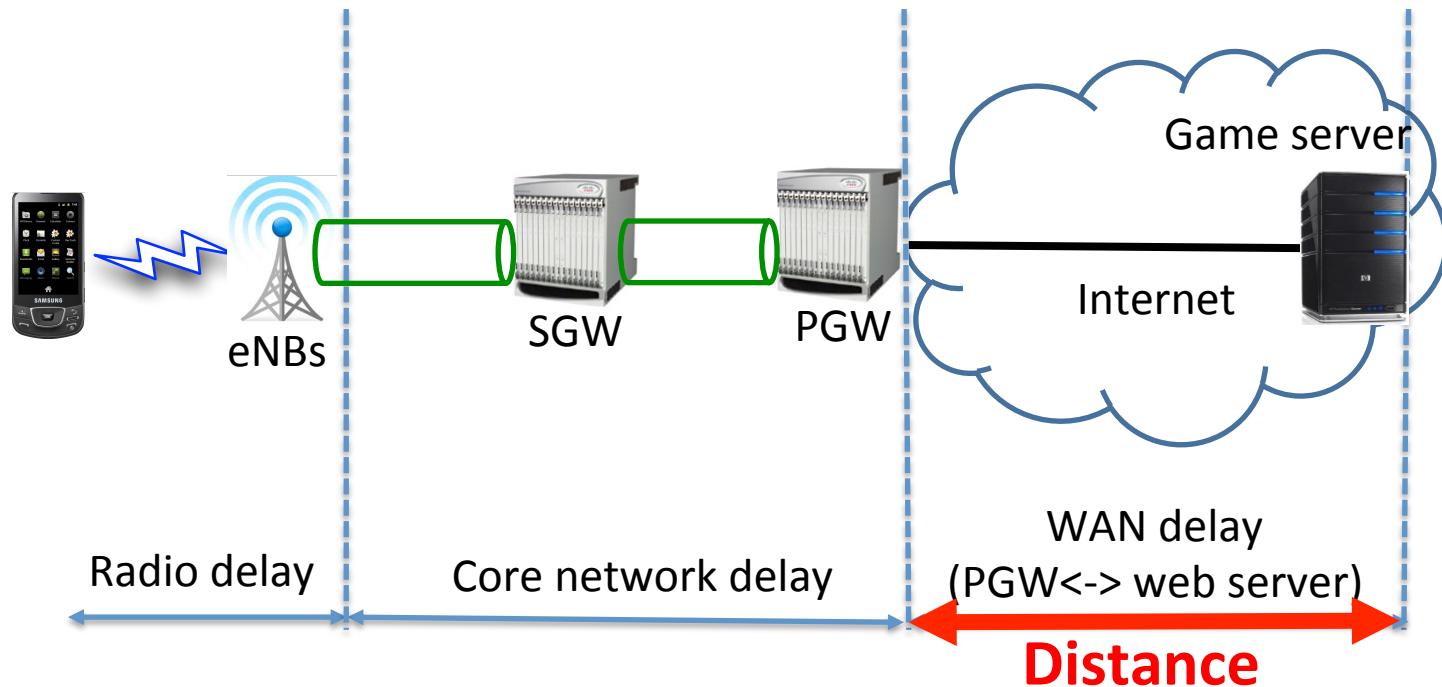
Motivation

LTE/EPC Mobile Network



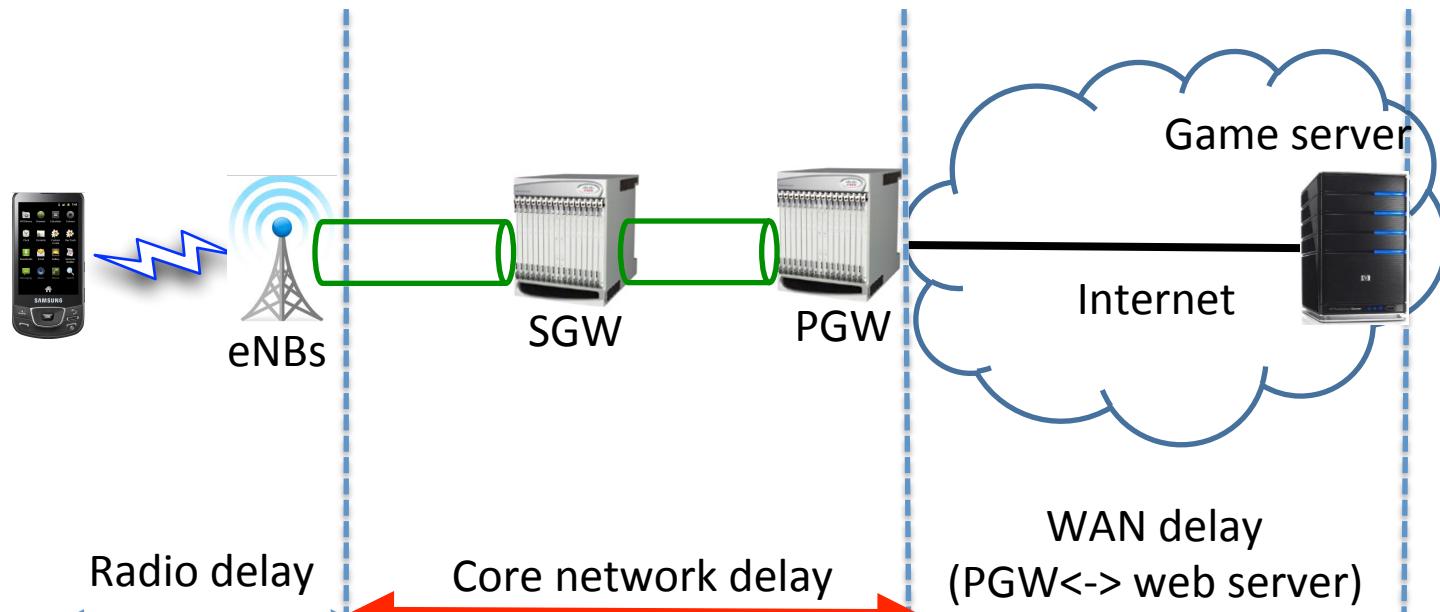
Motivation

LTE/EPC Mobile Network



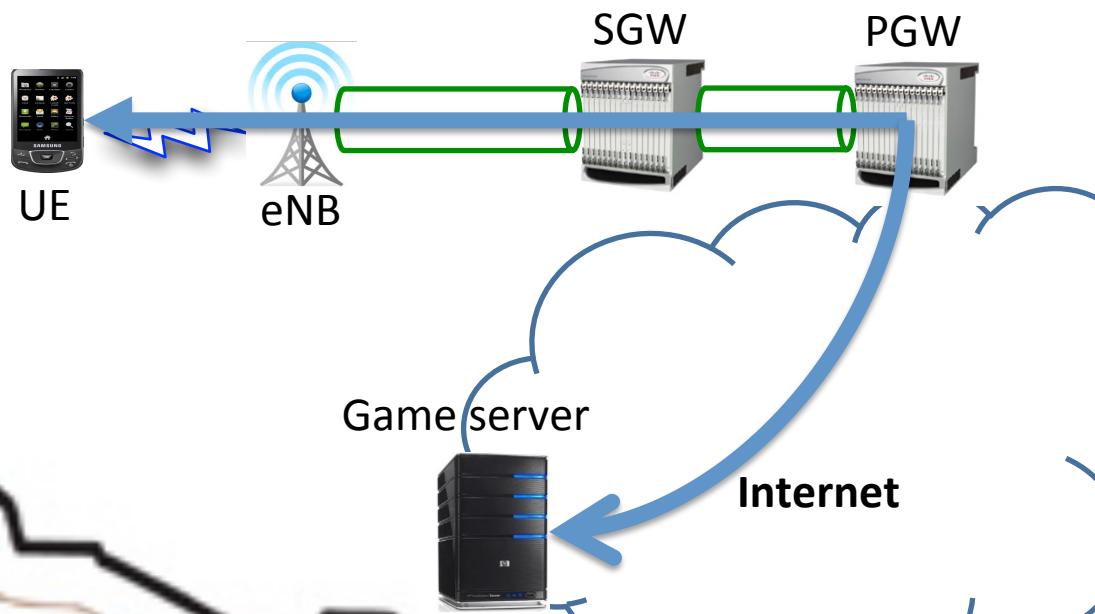
Motivation

LTE/EPC Mobile Network



Hierarchical routing

Hierarchical Routing

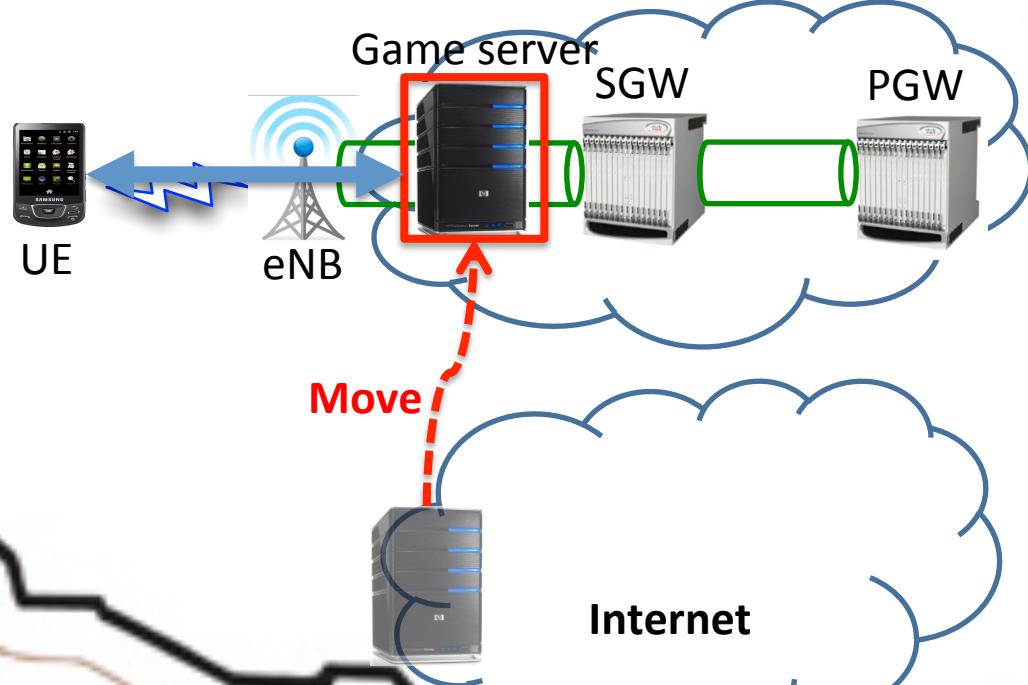


The number of eNodeBs >>>>>>> The number of S/PGW

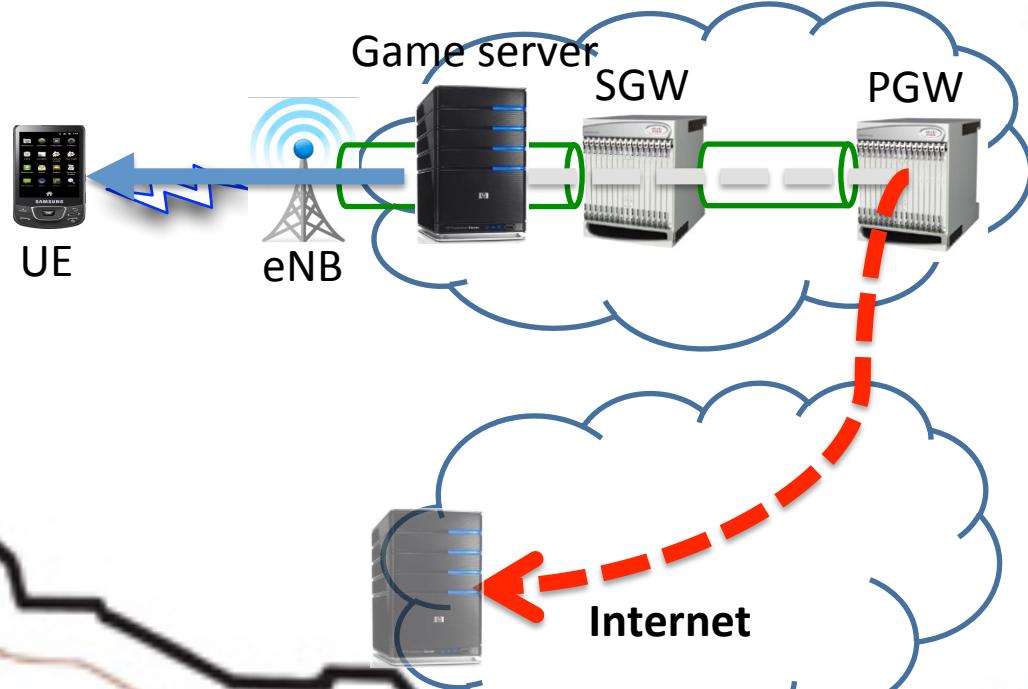
Motivation

LTE/EPC mobile network is still not enough for delay-sensitive applications like online gaming

Potential Solution : Offloading

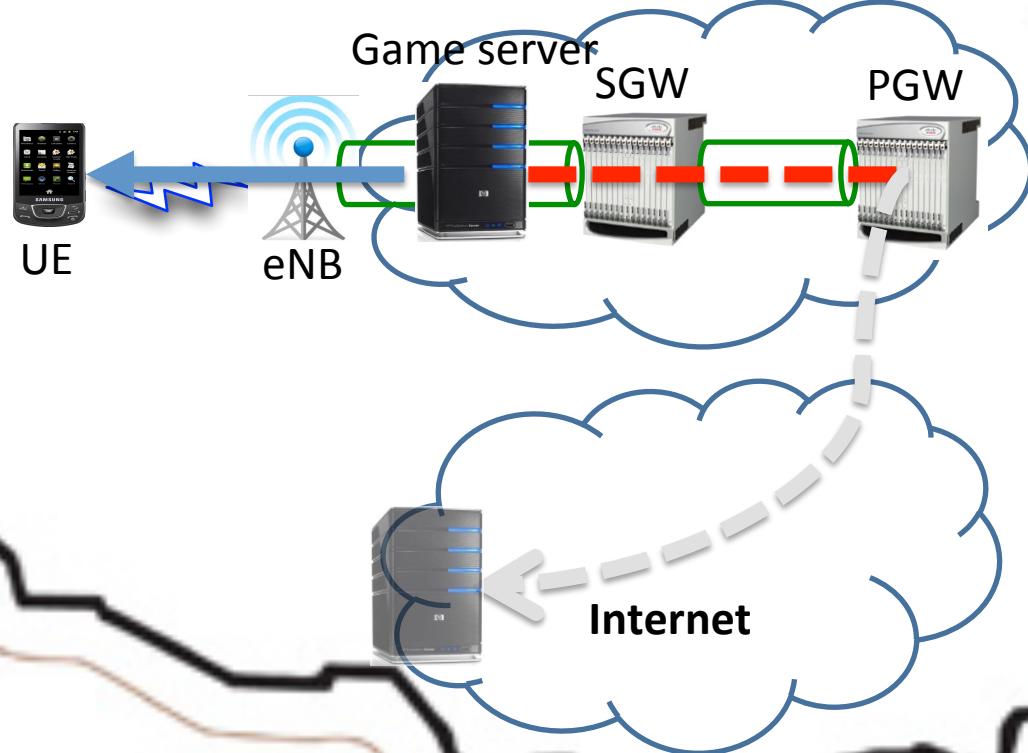


Potential Solution : Offloading



Removing delay between PGW and Internet

Potential Solution : Offloading



Alleviating delay from hierarchical routing

Goals

Provide mobile offloading architecture with traffic offloading and software-define network

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Provide mobile offloading architecture with traffic offloading and software-define network

Software-Define Network(SDN)

- Possible fine-grained traffic control on demand
- Selectively offload traffic based on flow rules

Goals

However, approaches are not new

Key contributions

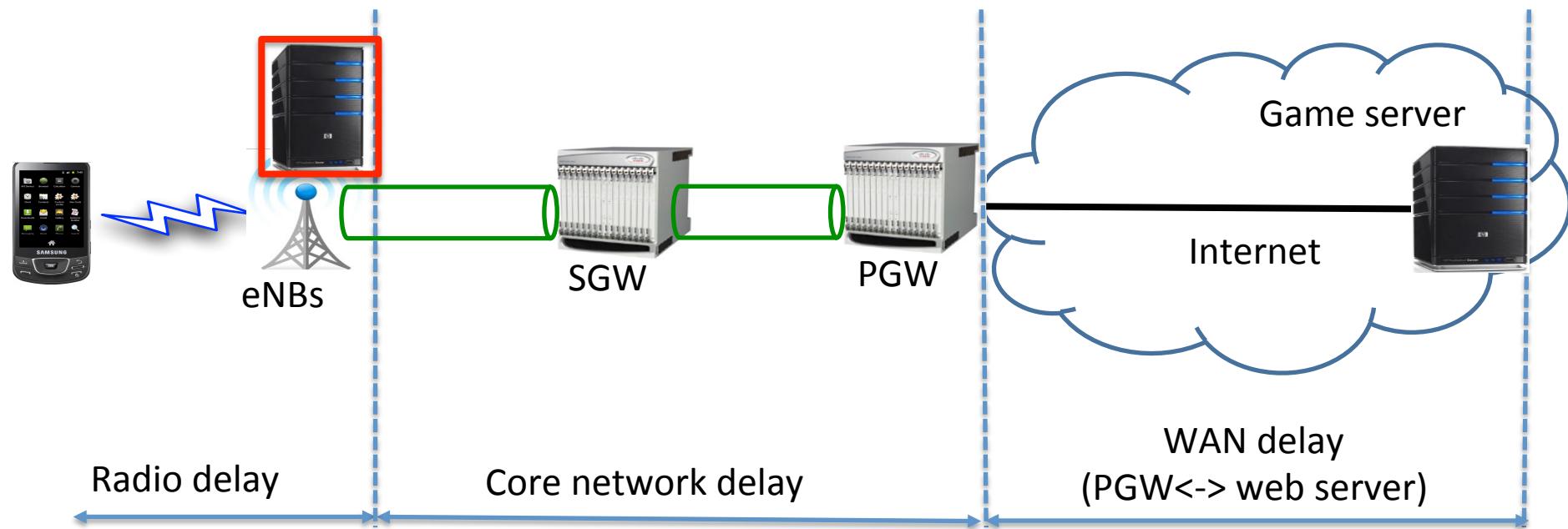
- **Transparent to existing LTE/EPC mobile network**
 - No requirement to modify LTE/EPC architecture and 3gpp standard since it is not easy to change them
- Built working prototype
 - It supports traffic offloading even when handover happens

Sweet Spot for location of offloading servers

- Related to business between mobile carrier and service provider
 - Cost, delay and coverage effective location for offloading servers

Near eNodeBs

LTE/EPC Mobile Network



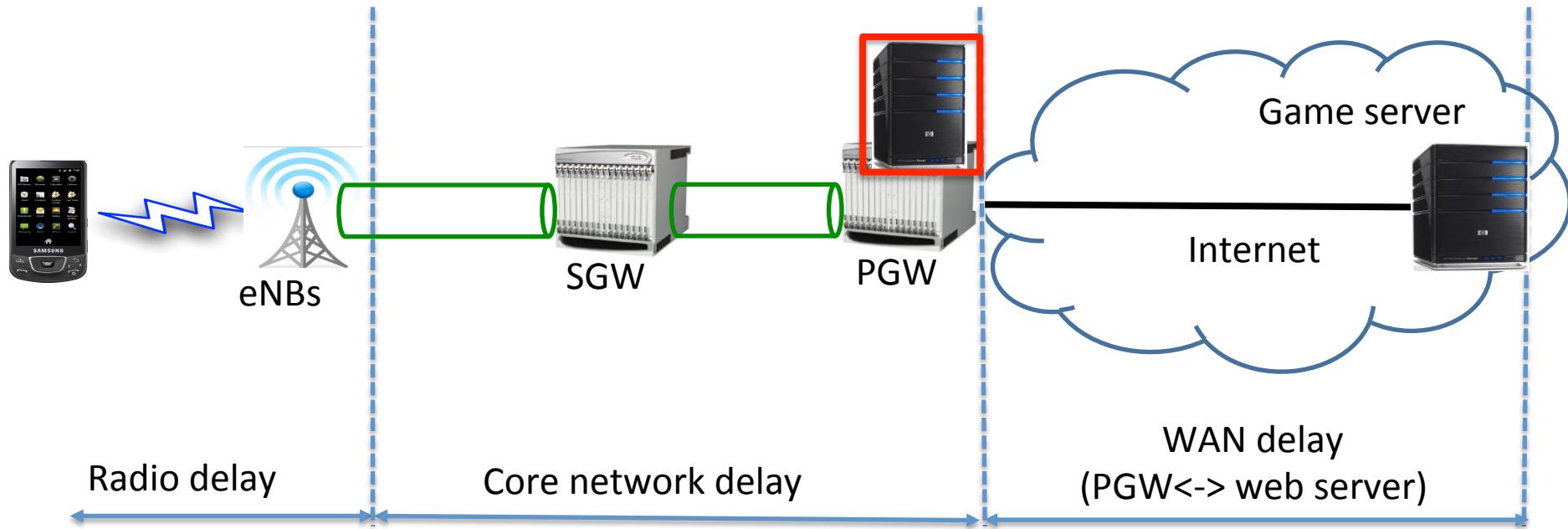
~ thousands of eNBs

+ Best latency

- A lot of deployment cost

Near PGWs

LTE/EPC Mobile Network



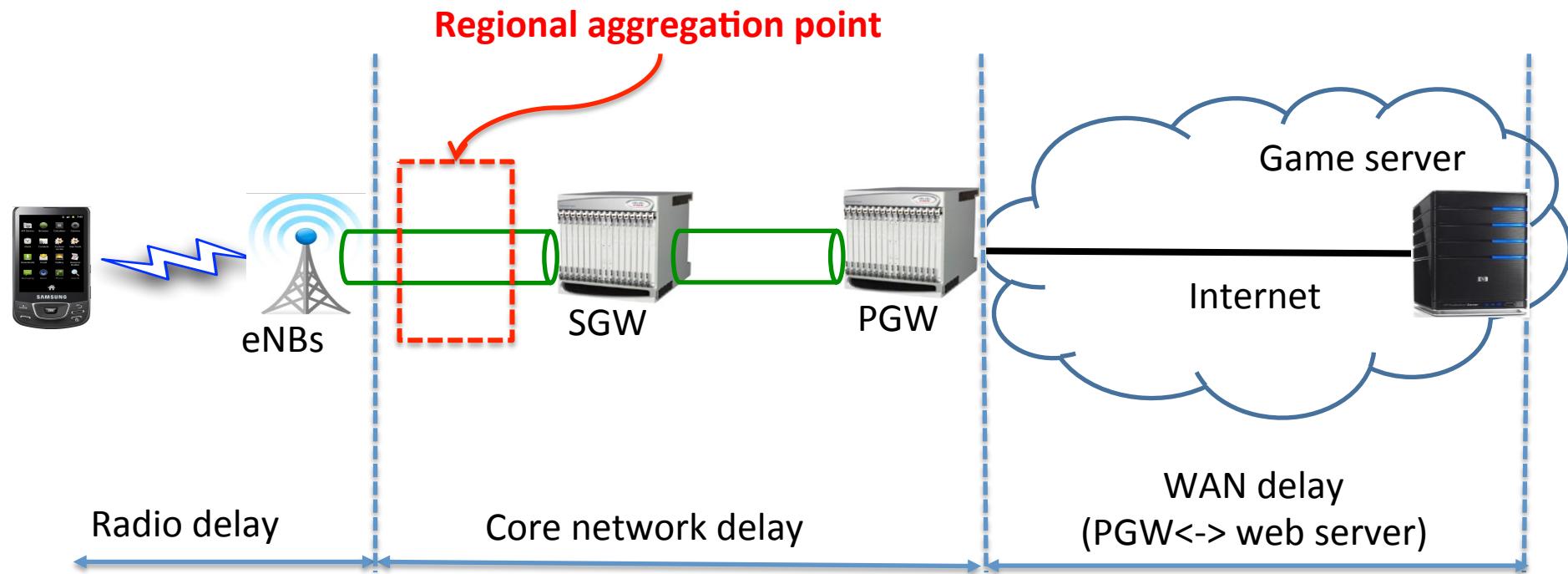
~ low tens of PGW

+ Small deployment cost

- Worst latency

Regional aggregation points

LTE/EPC Mobile Network

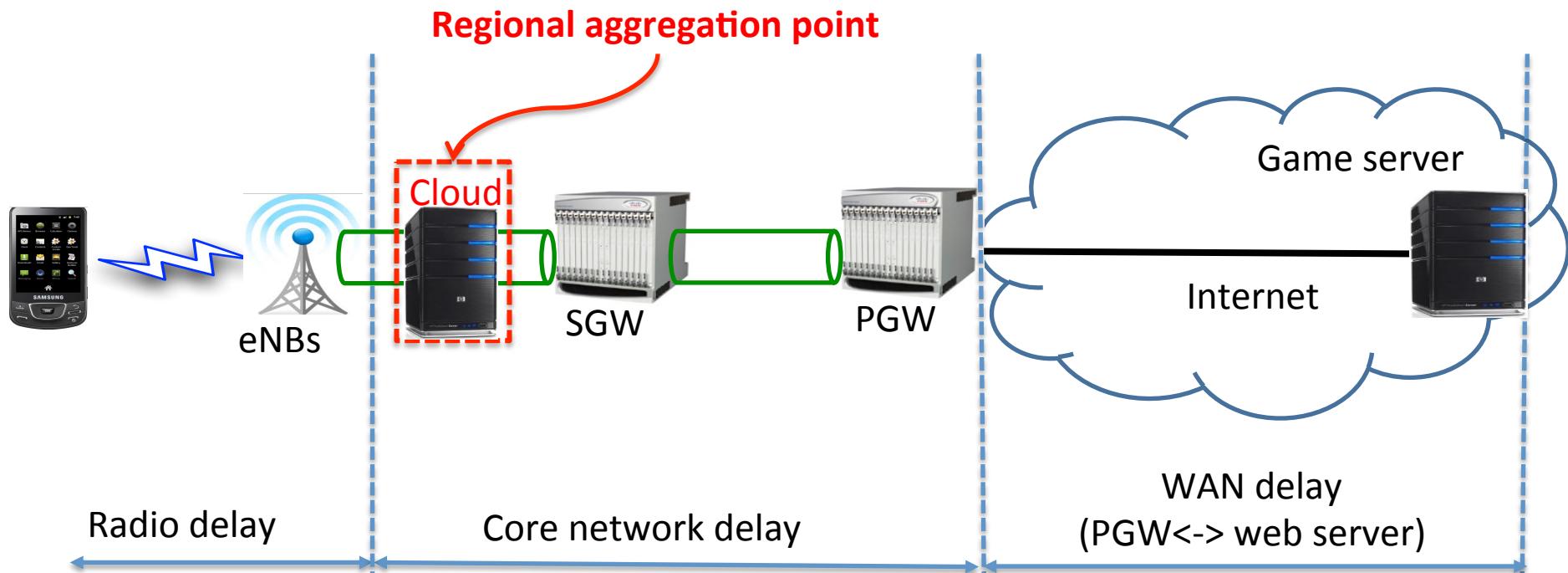


~ 100 – 150 regional aggregation points

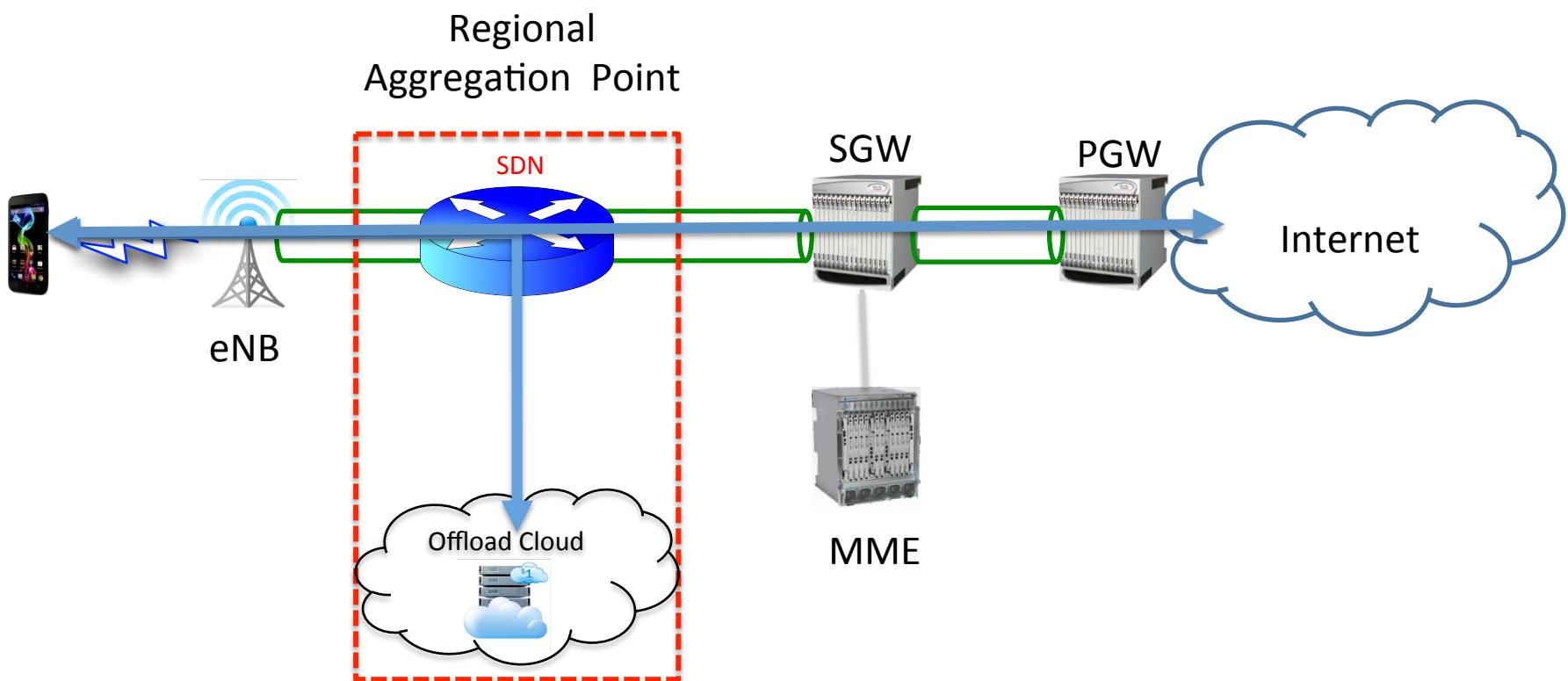
- **It covers a large metropolitan area**
- **Reasonable location in terms of cost and delay**

Regional aggregation points

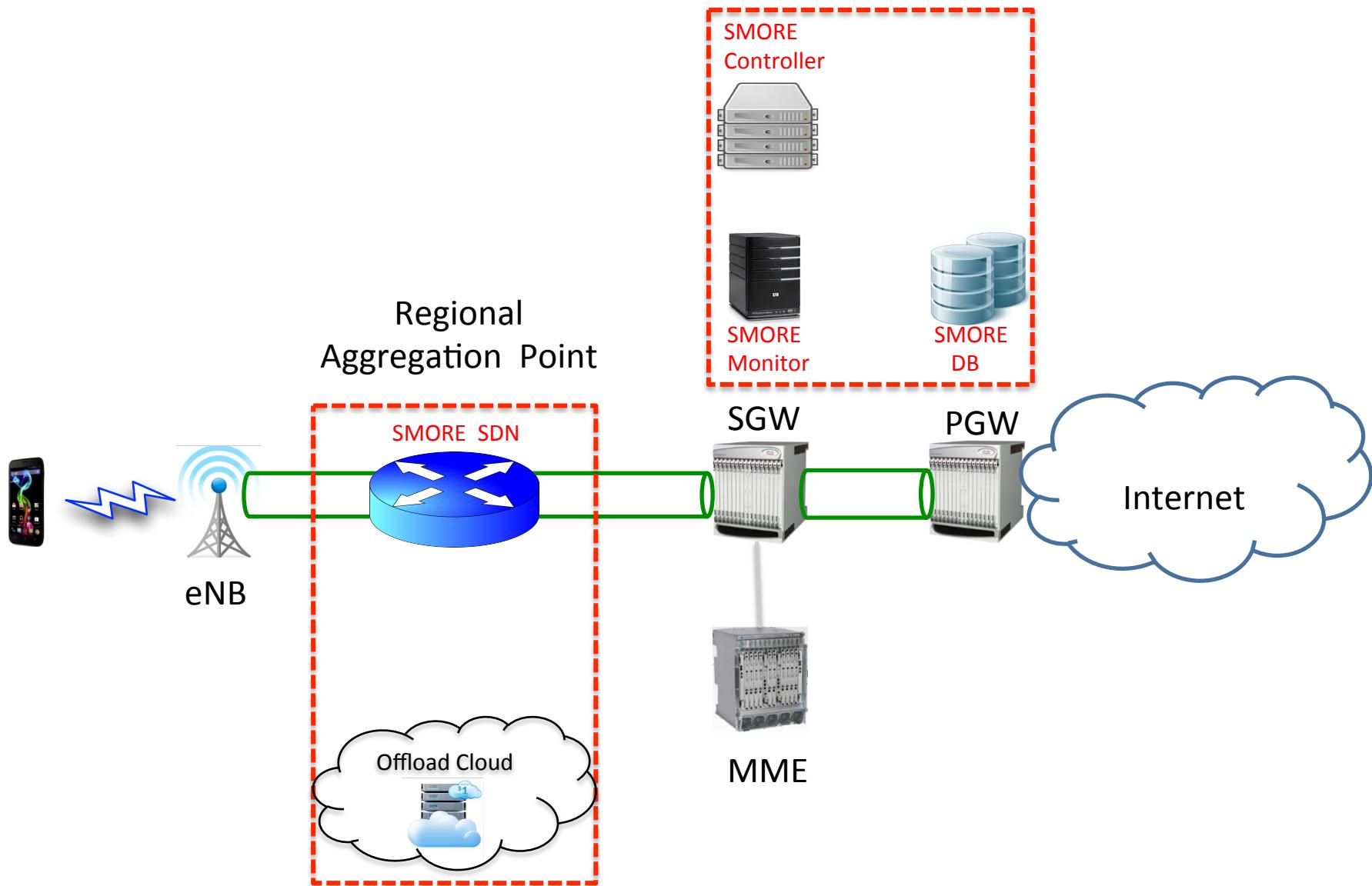
LTE/EPC Mobile Network



Offloading Infrastructure



SMORE Architecture

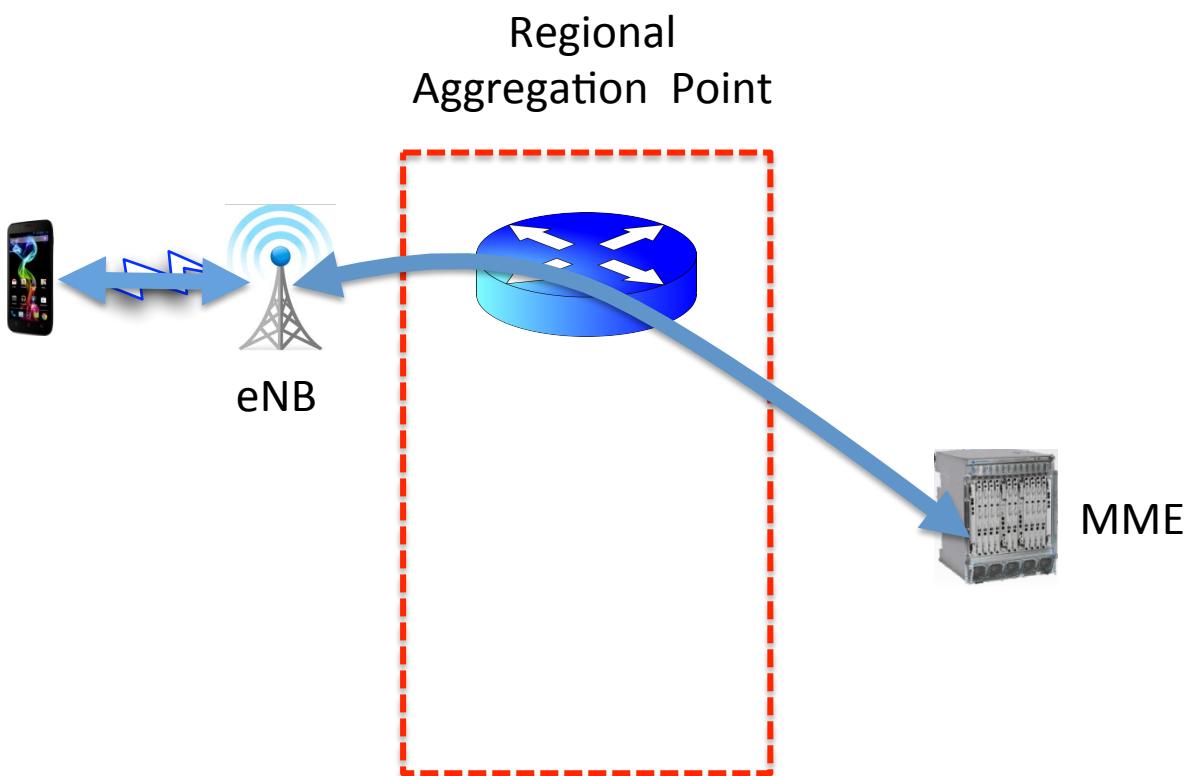


SMORE Use Cases

- On-demand use case
- Subscription use case

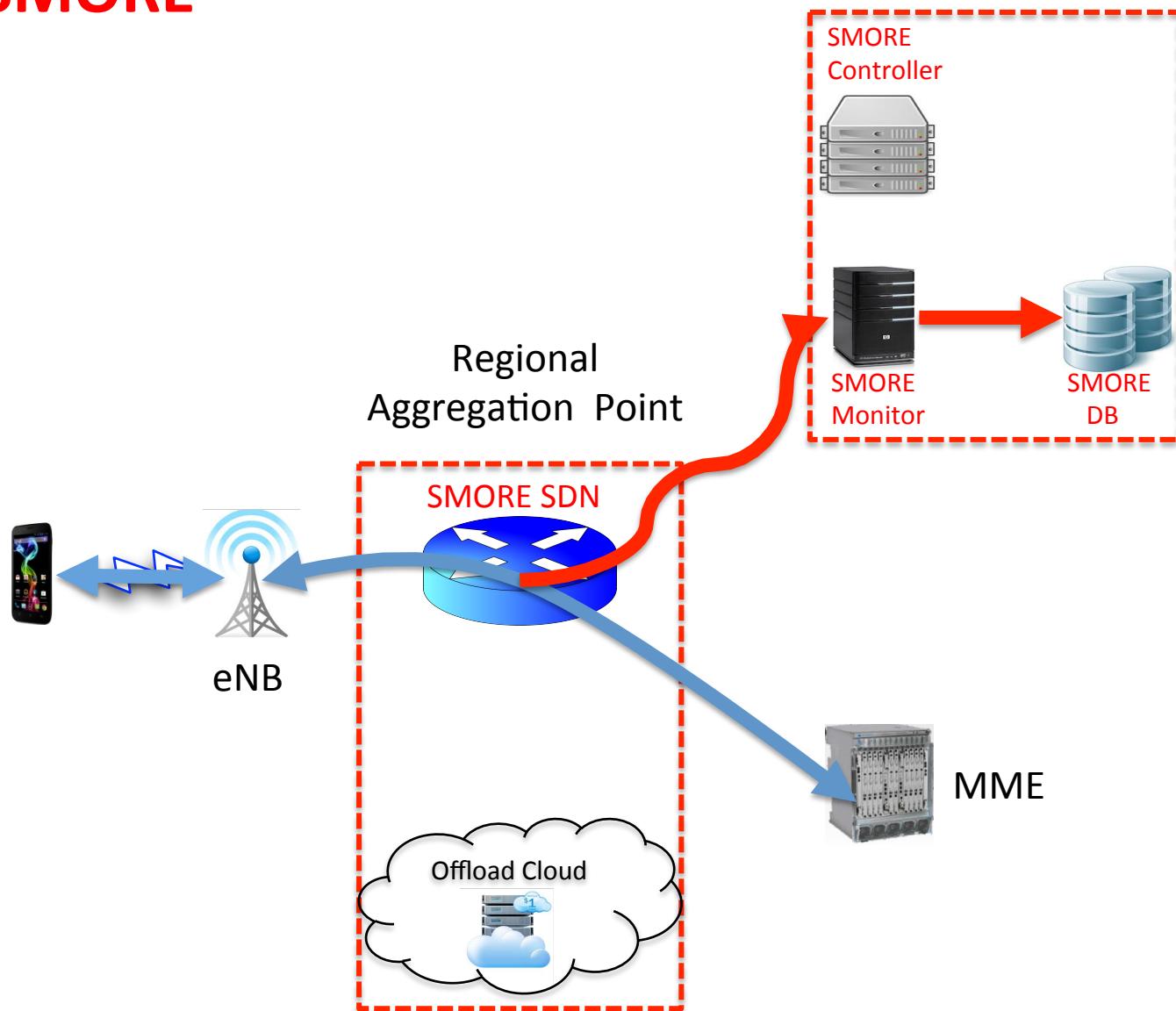
On-demand Use Case

LTE/EPC Mobile Network

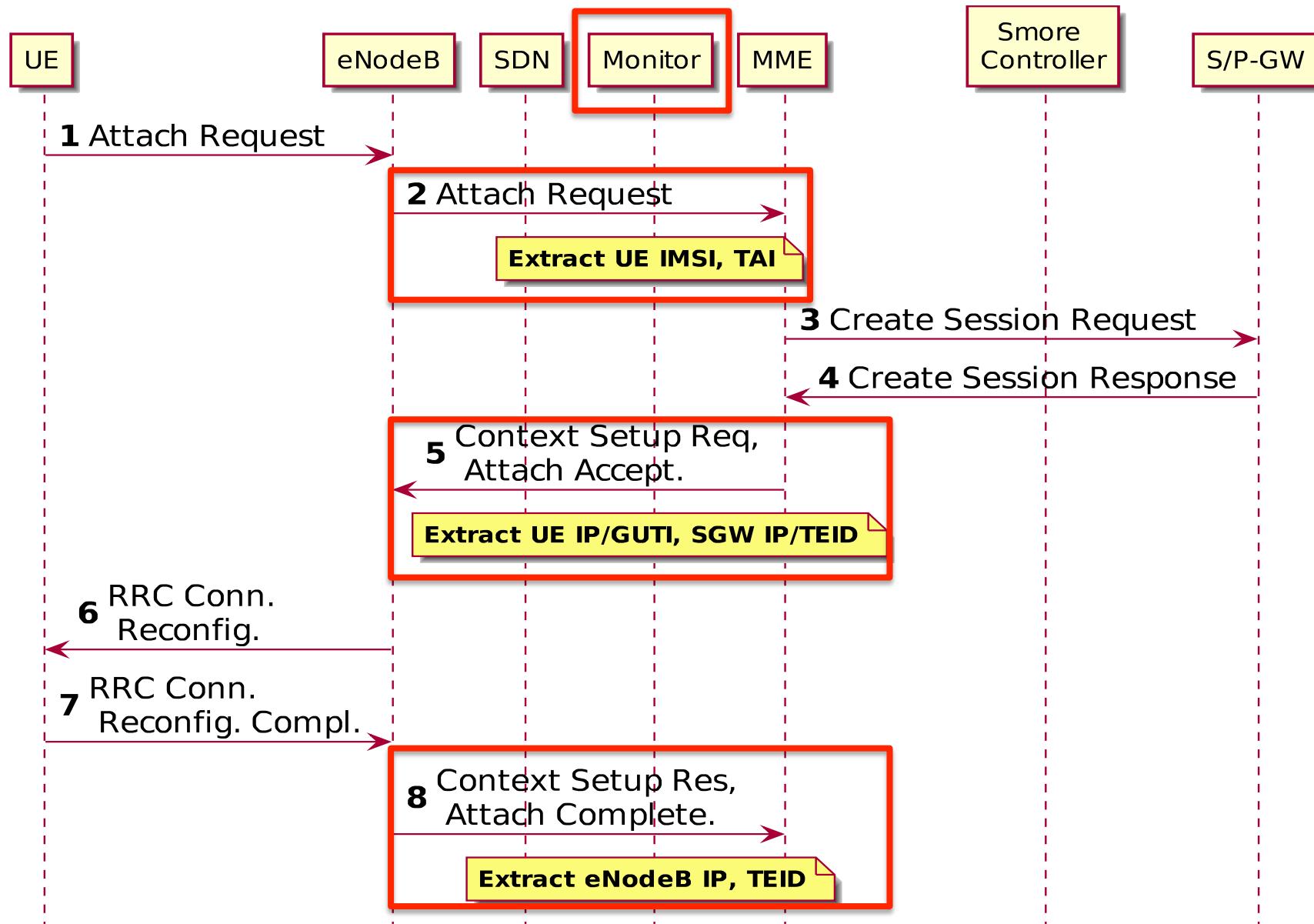


On-demand Use Case

SMORE

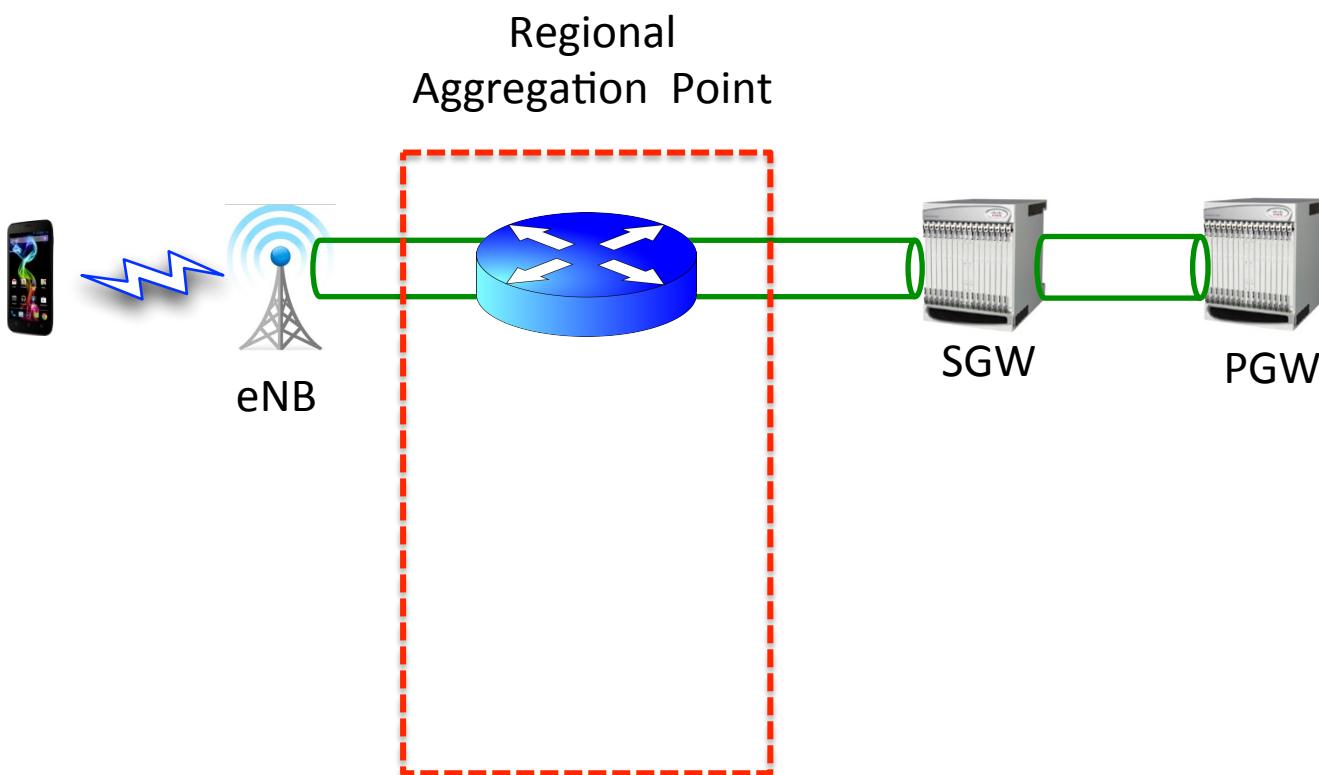


Extract Info from Attach Event



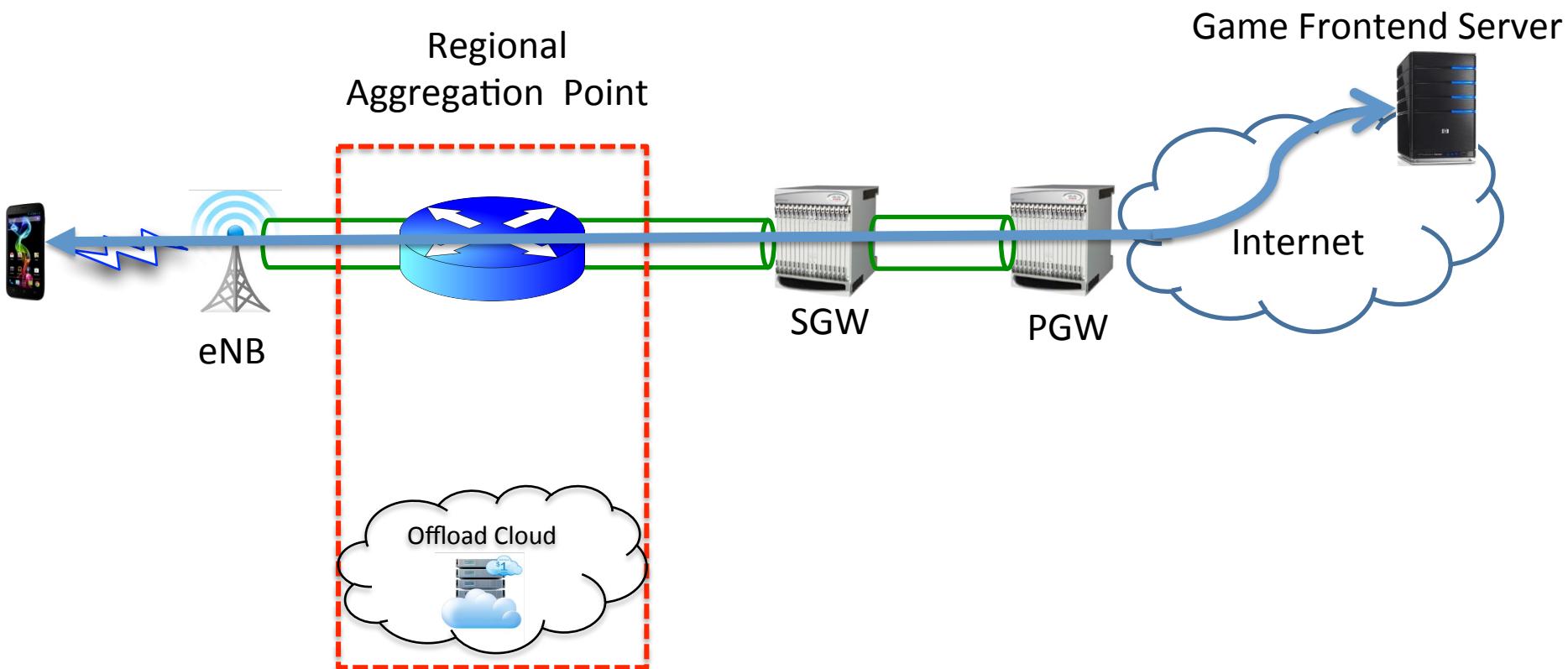
On-demand Use Case

LTE/EPC Mobile Network



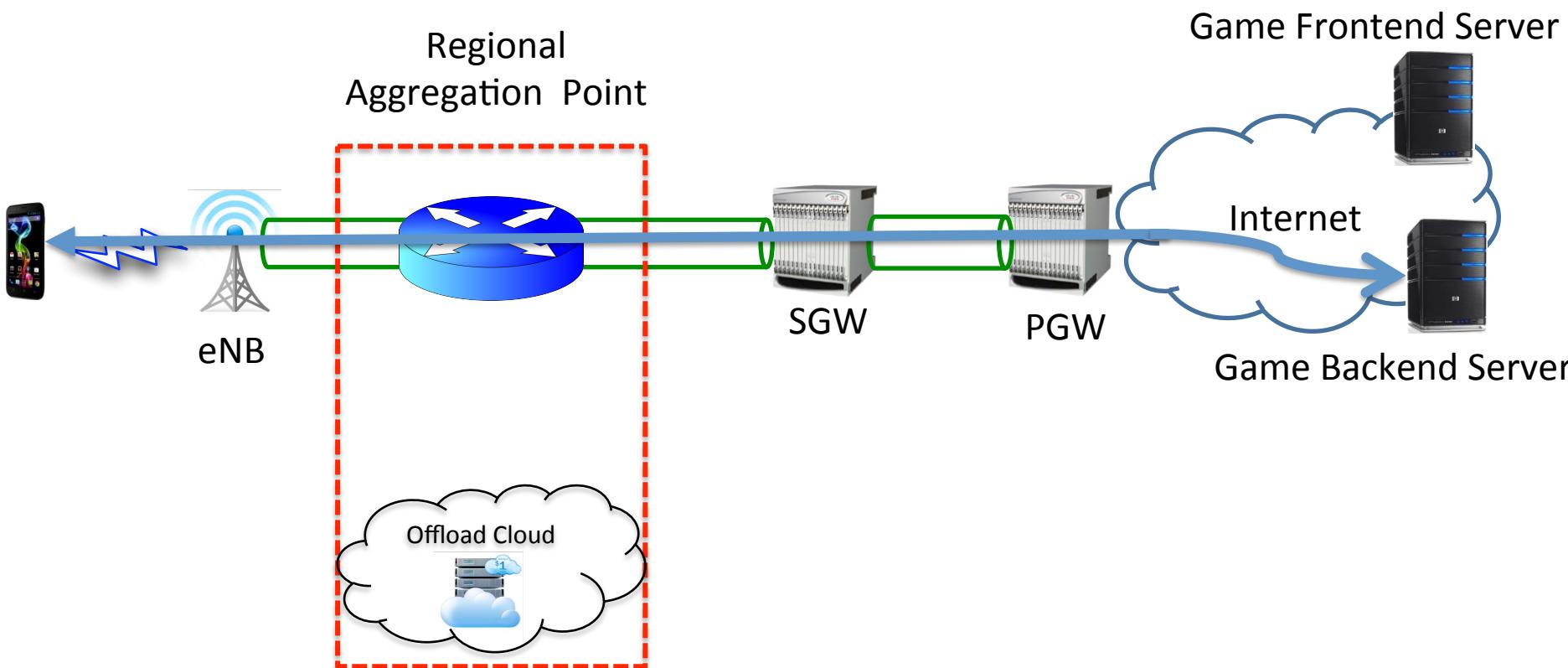
On-demand Use Case

LTE/EPC Mobile Network



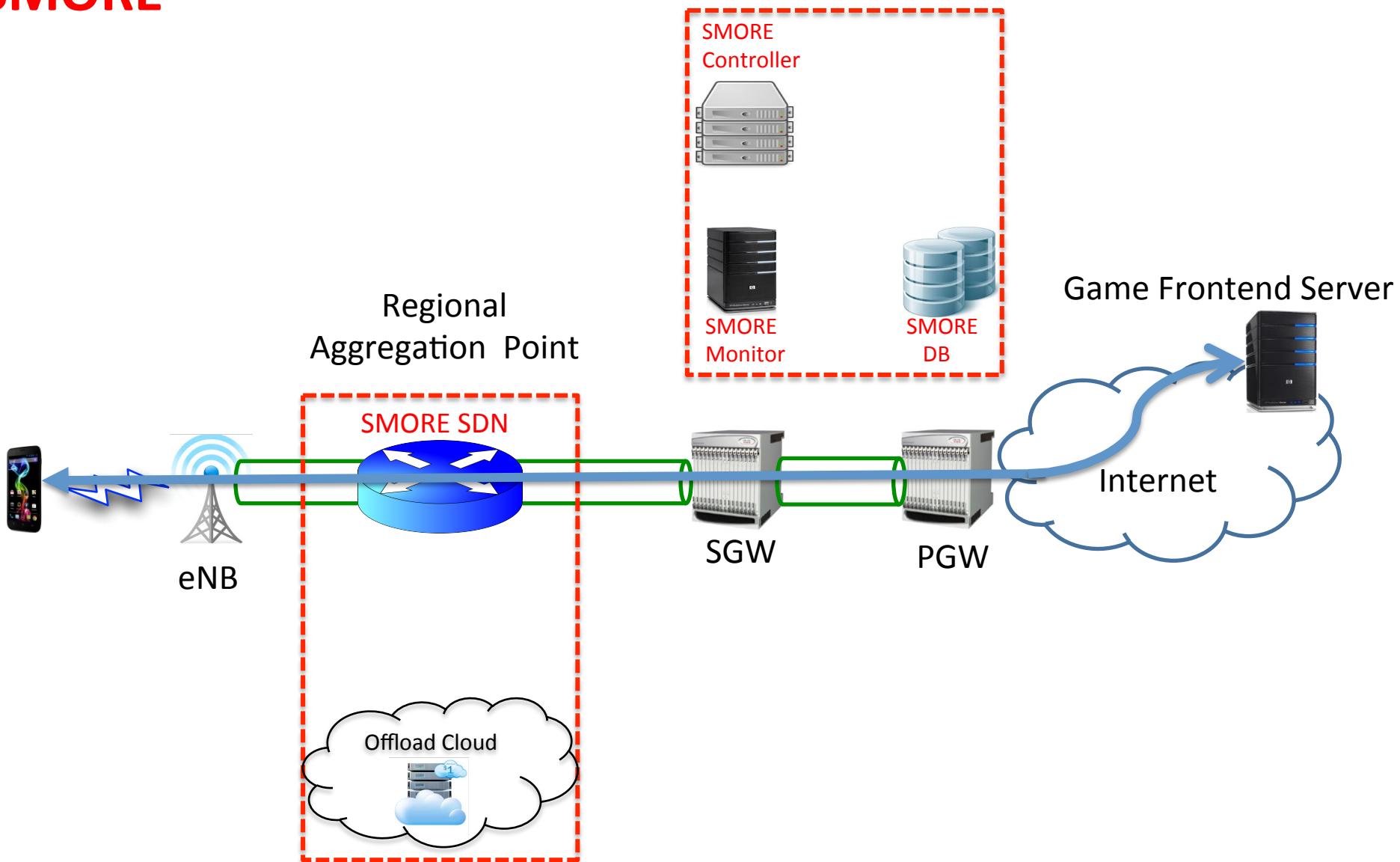
On-demand Use Case

LTE/EPC Mobile Network



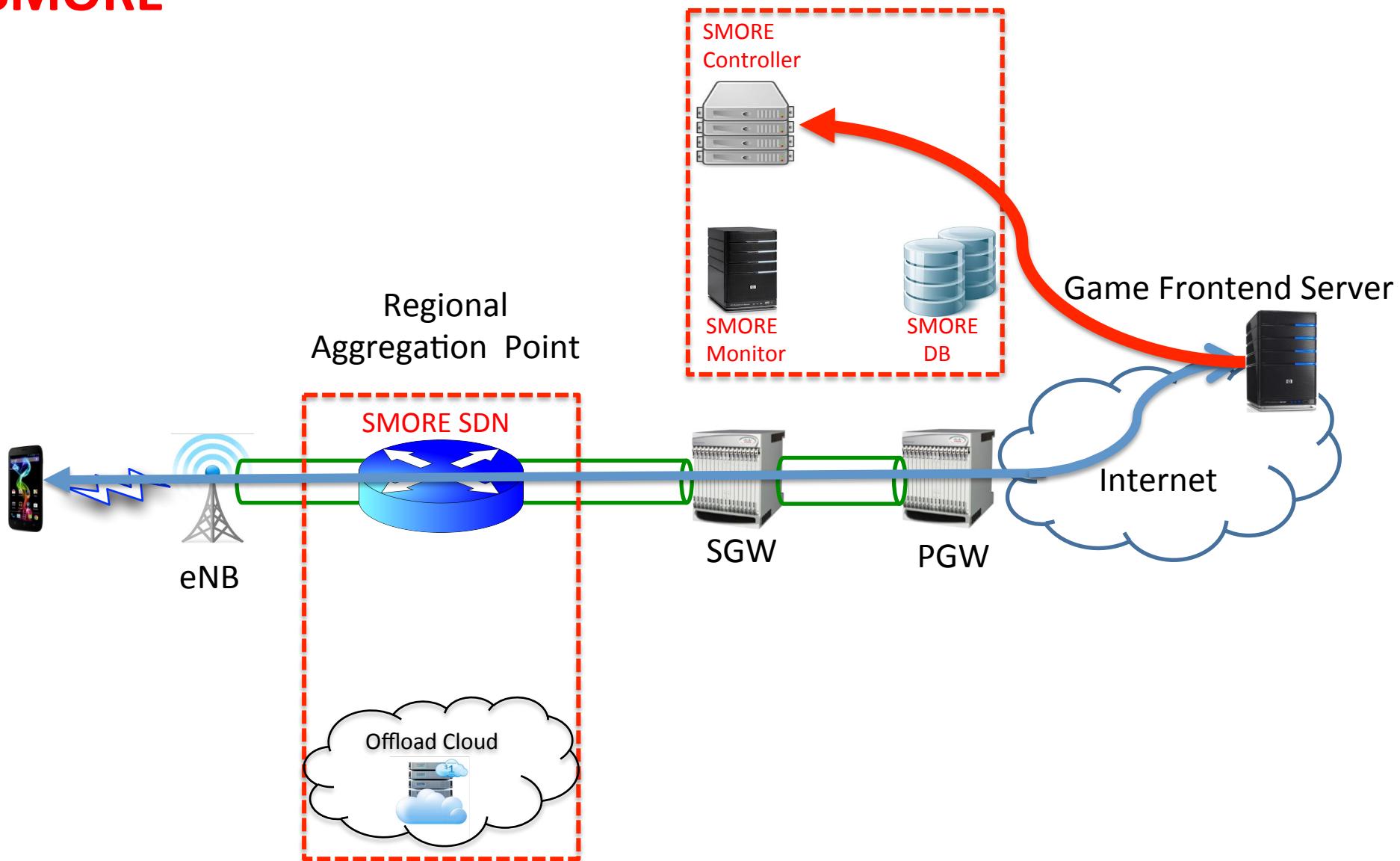
On-demand Use Case

SMORE



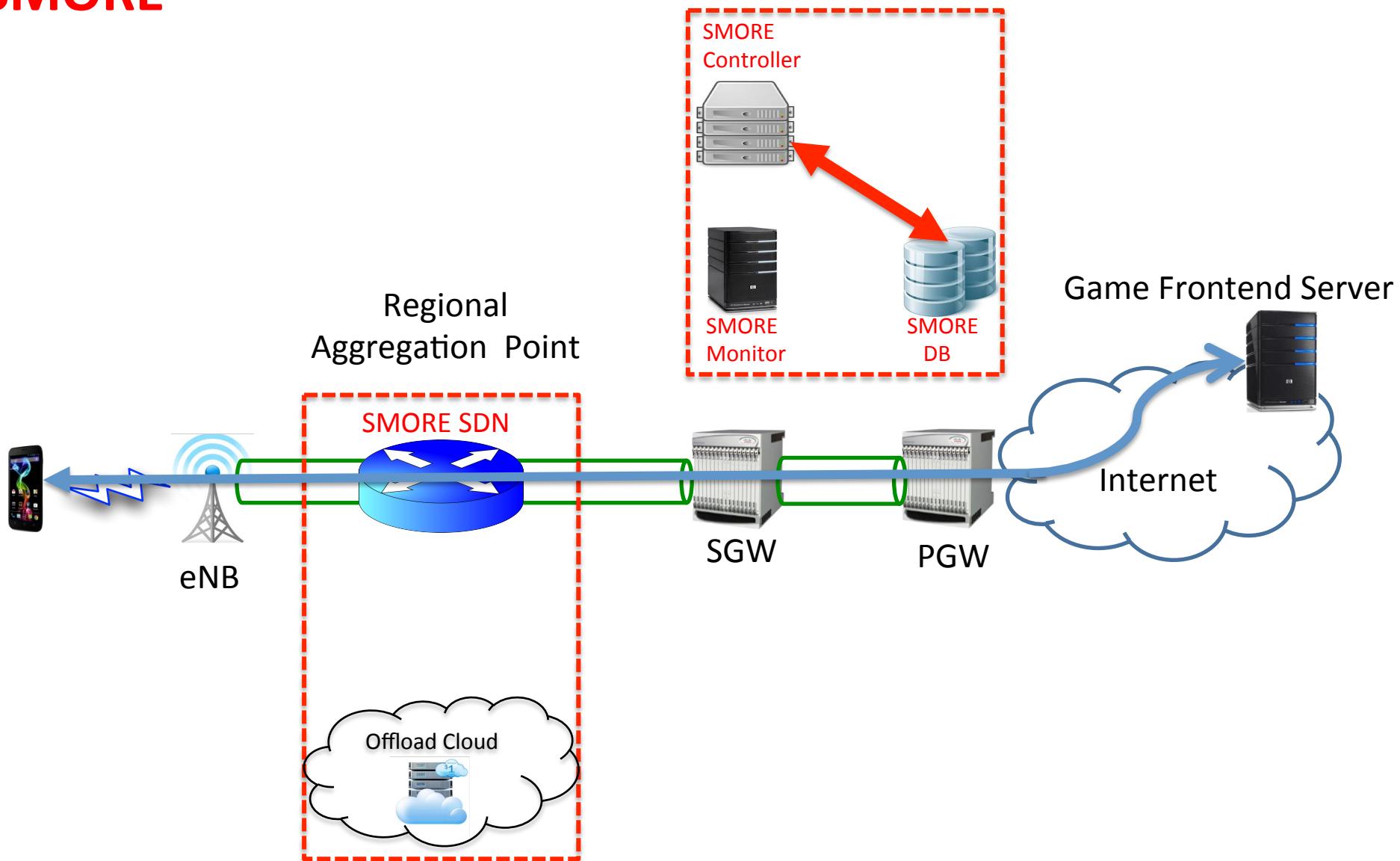
On-demand Use Case

SMORE



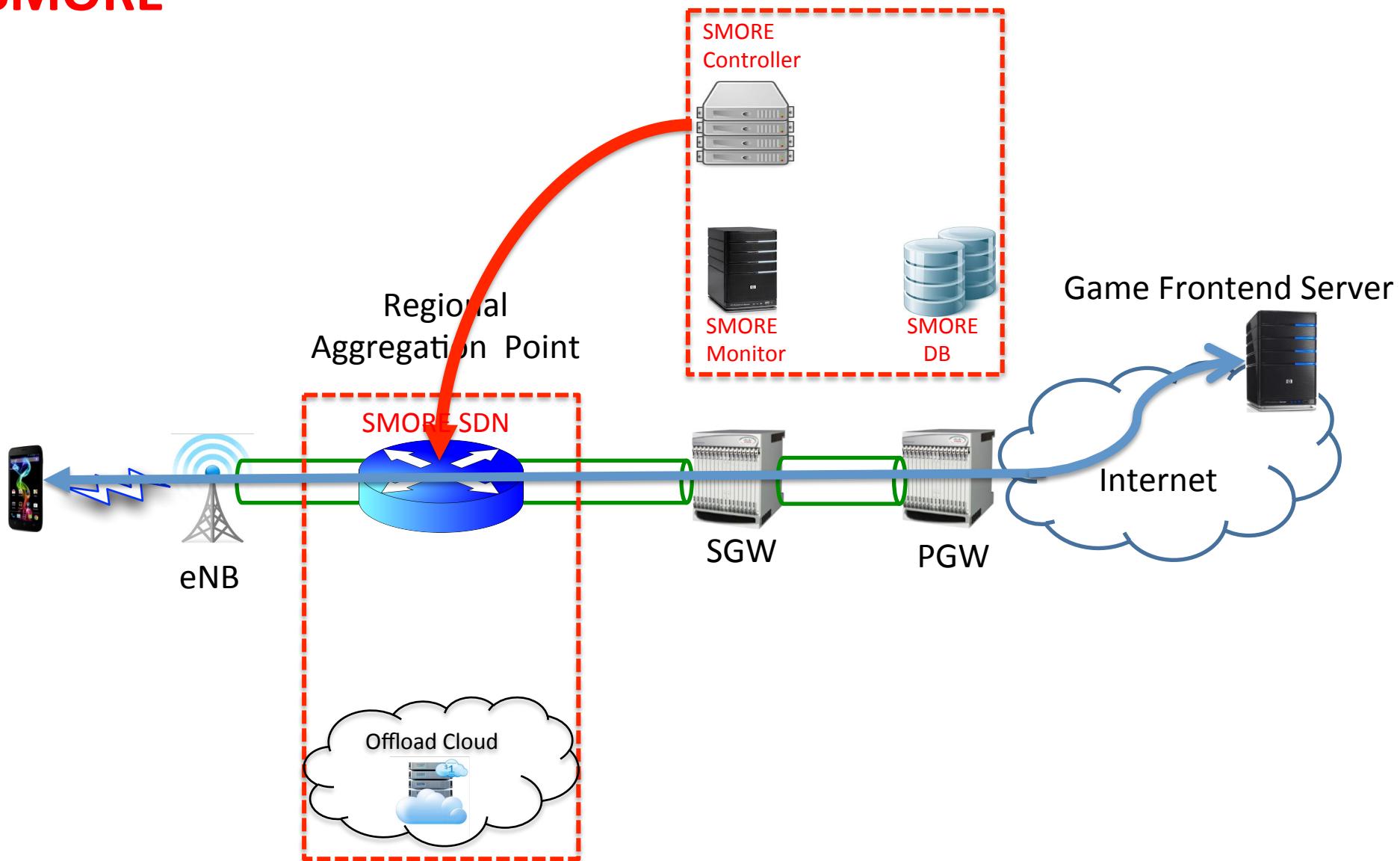
On-demand Use Case

SMORE



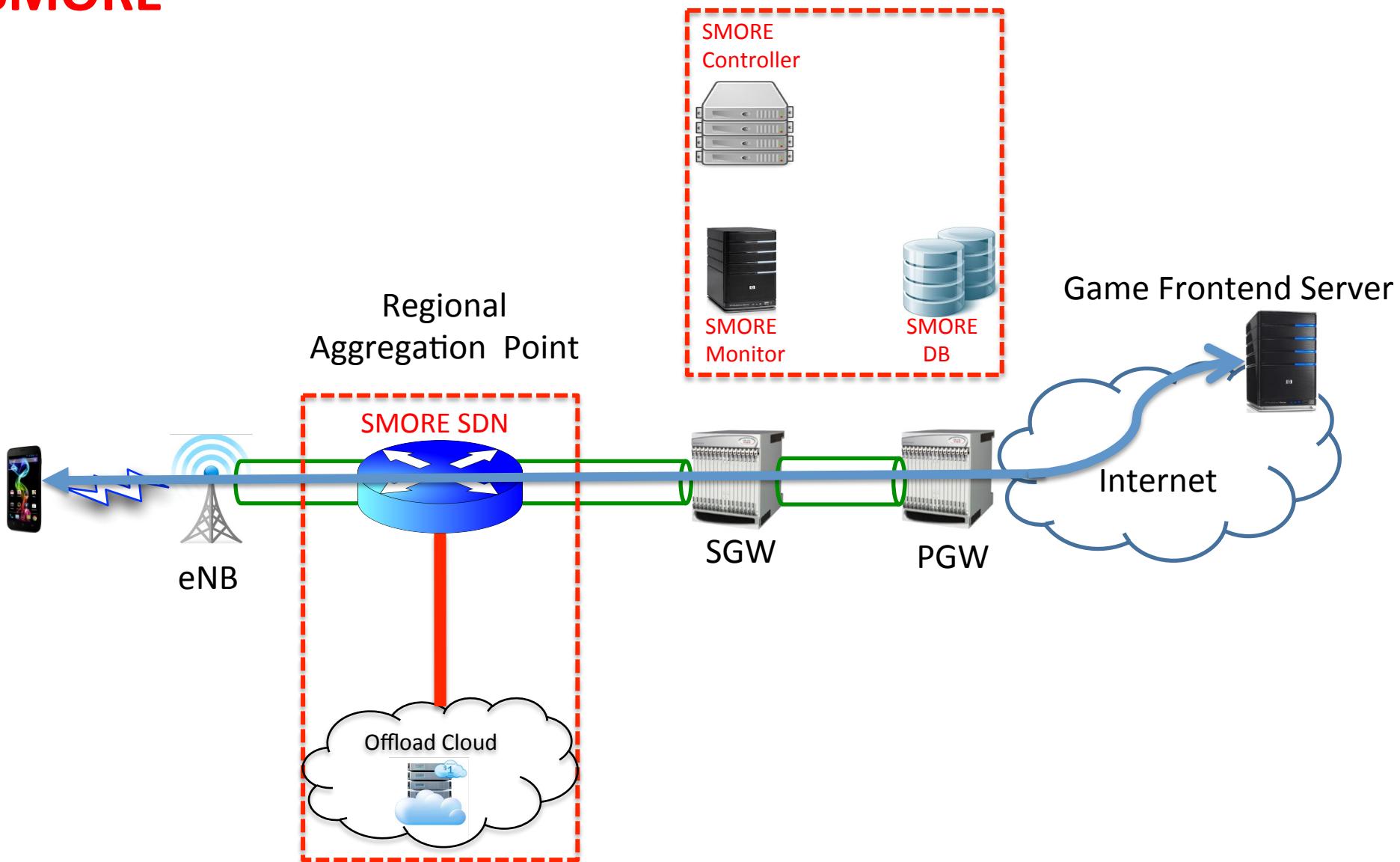
On-demand Use Case

SMORE



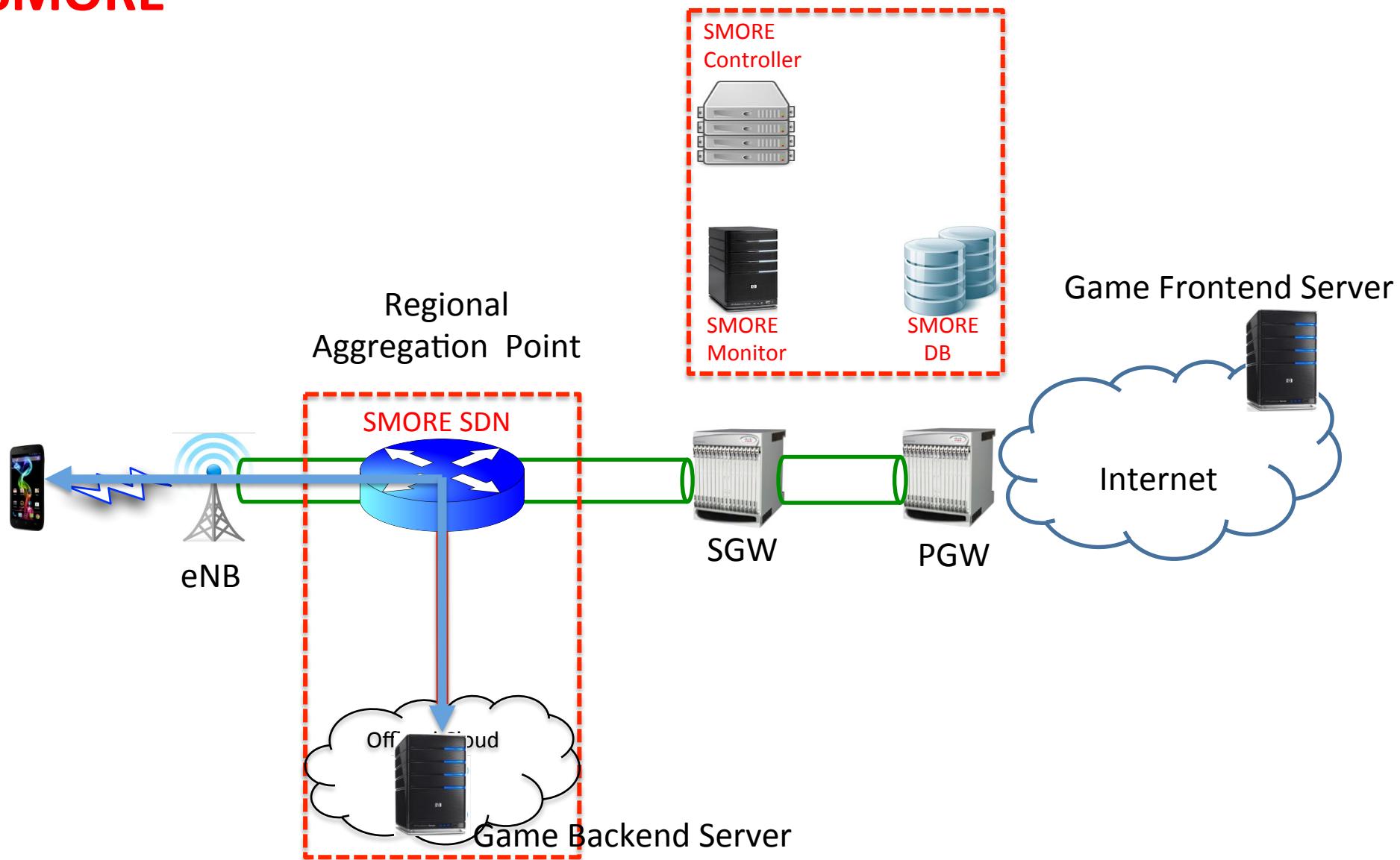
On-demand Use Case

SMORE



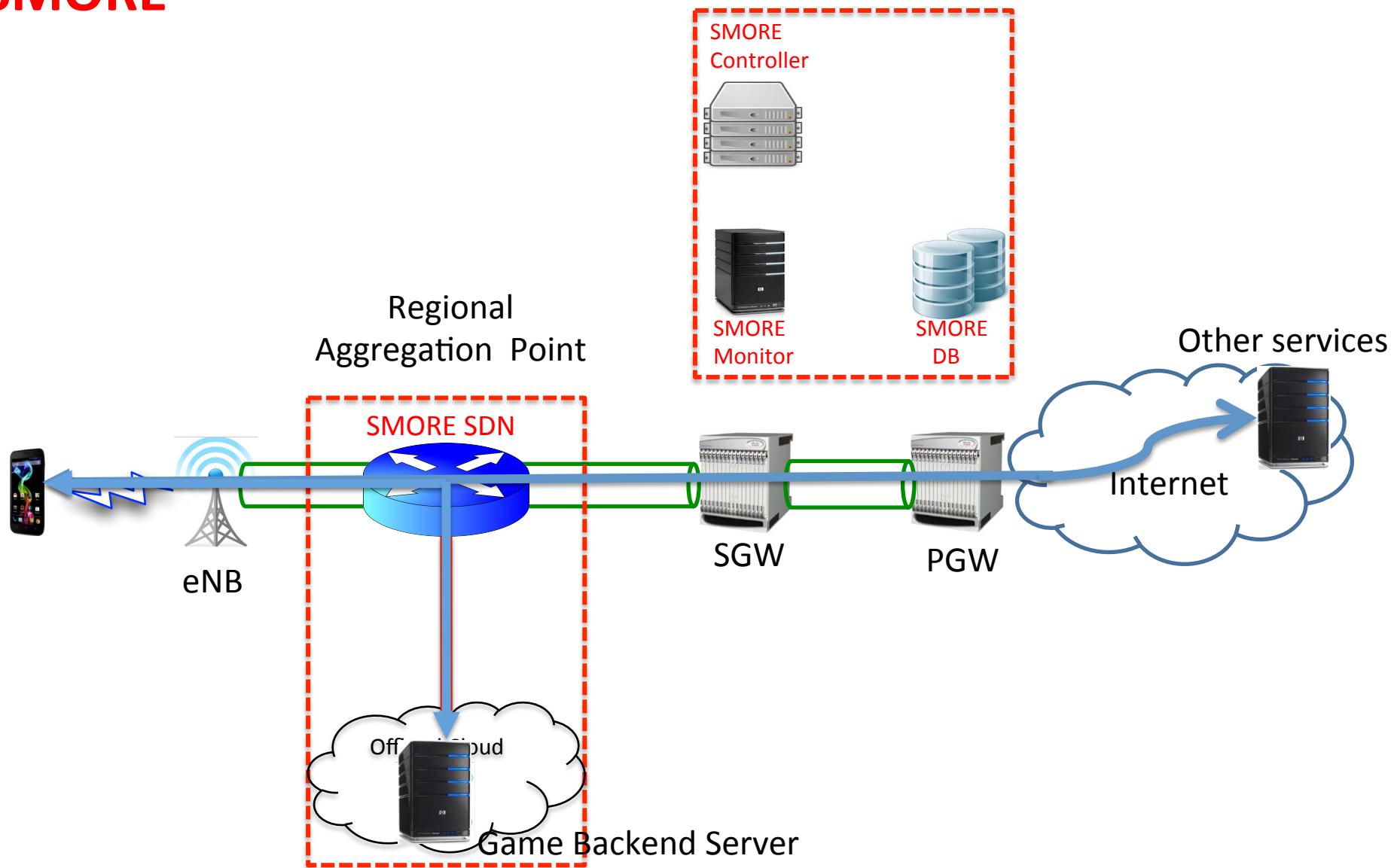
On-demand Use Case

SMORE



On-demand Use Case

SMORE



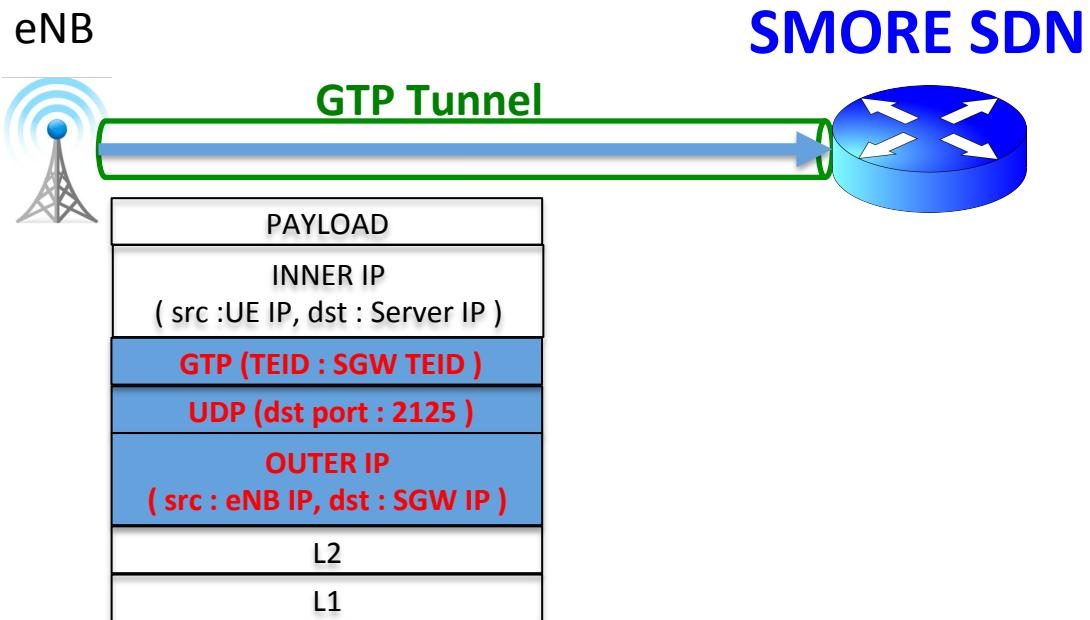
SMORE Components

- **SMORE SDN**
- SMORE Controller
- SMORE Monitor

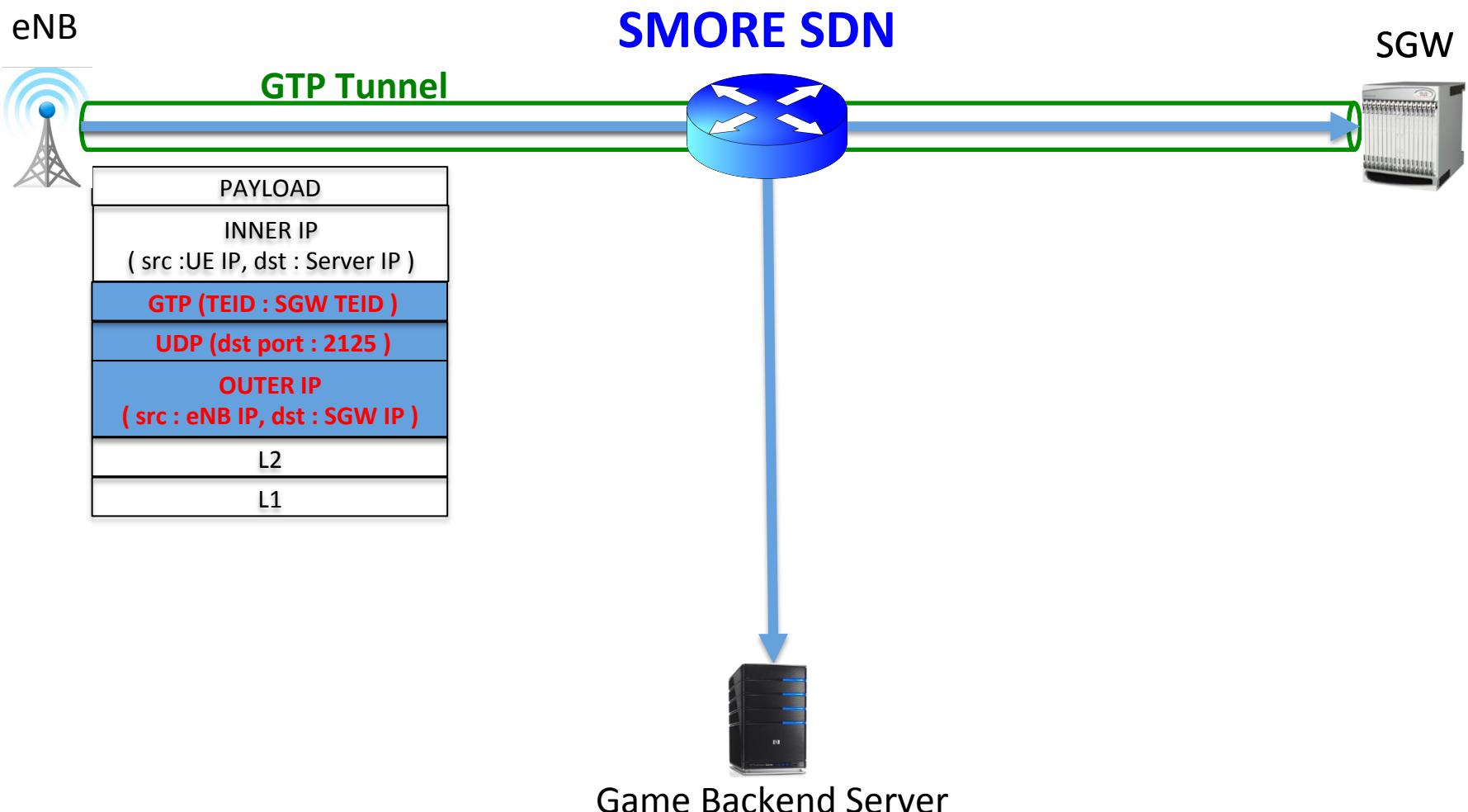
SMORE SDN

- SMORE SDN
 - Forward traffic based on flow-entries
 - Traffic offloading evaluation
 - GTP Tunnel en/decapsulation

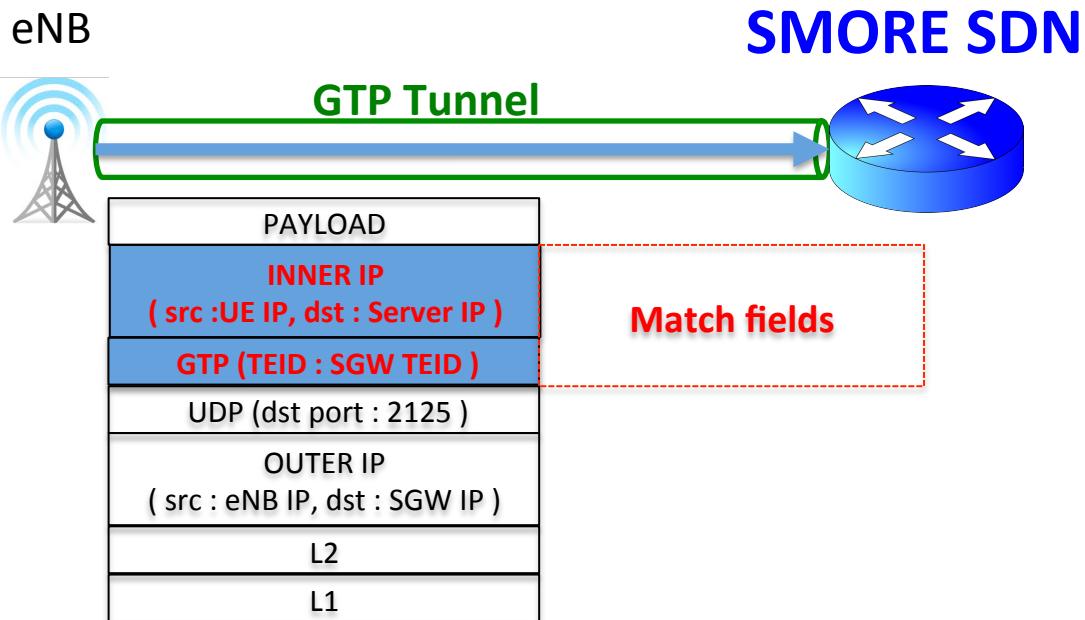
GPRS Tunnel Protocol (GTP)



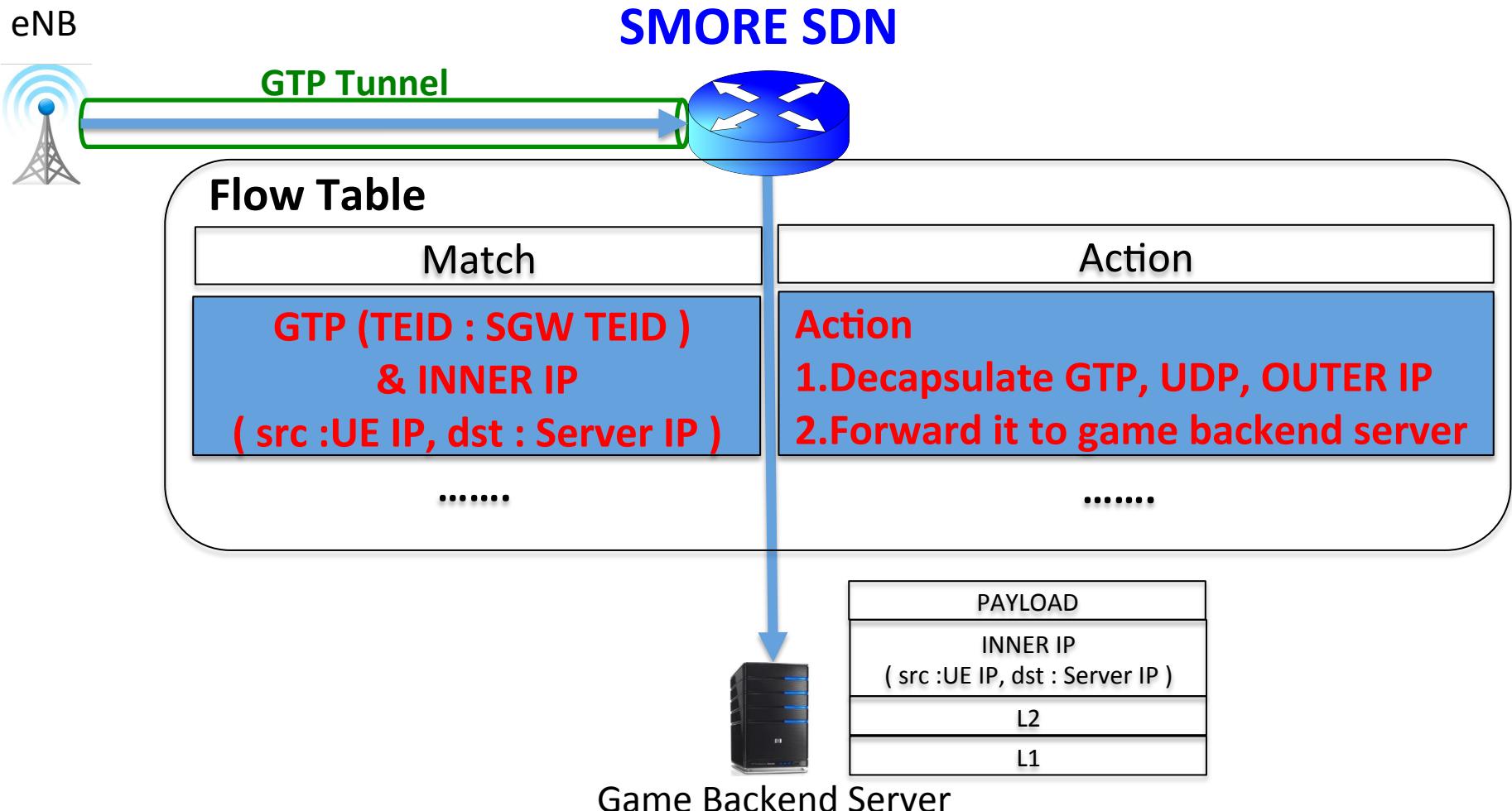
Two Possible Paths for Uplink Traffic



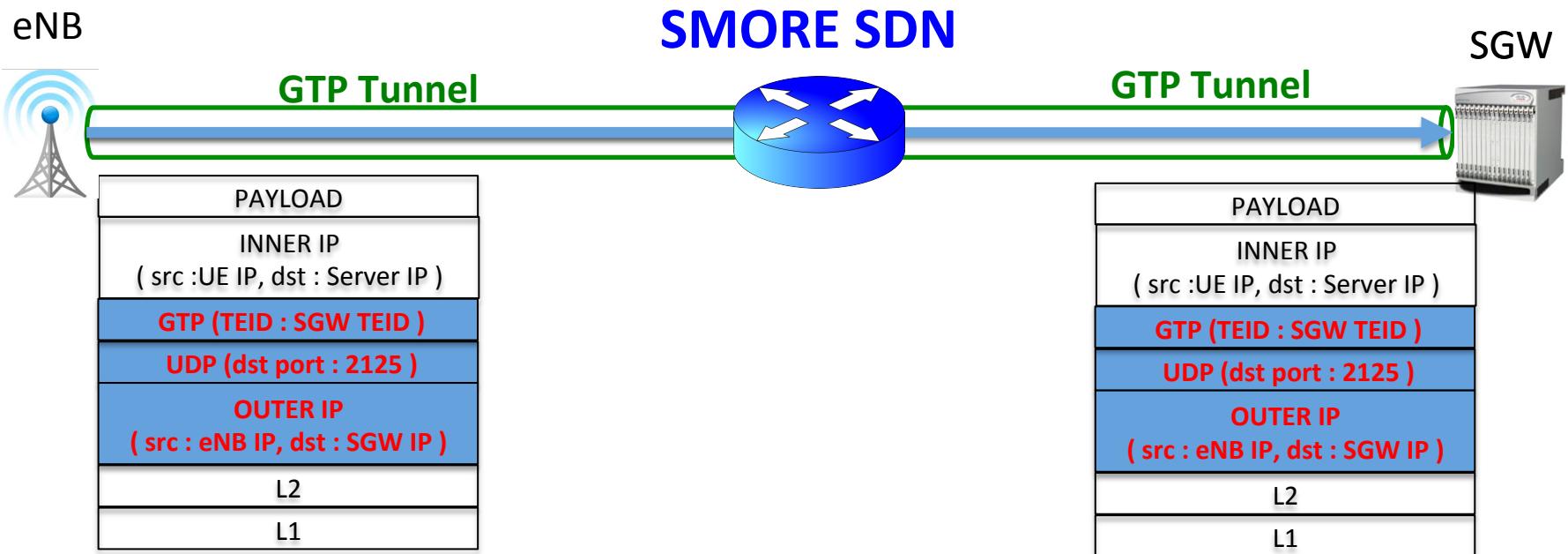
Match Rule for Uplink Traffic



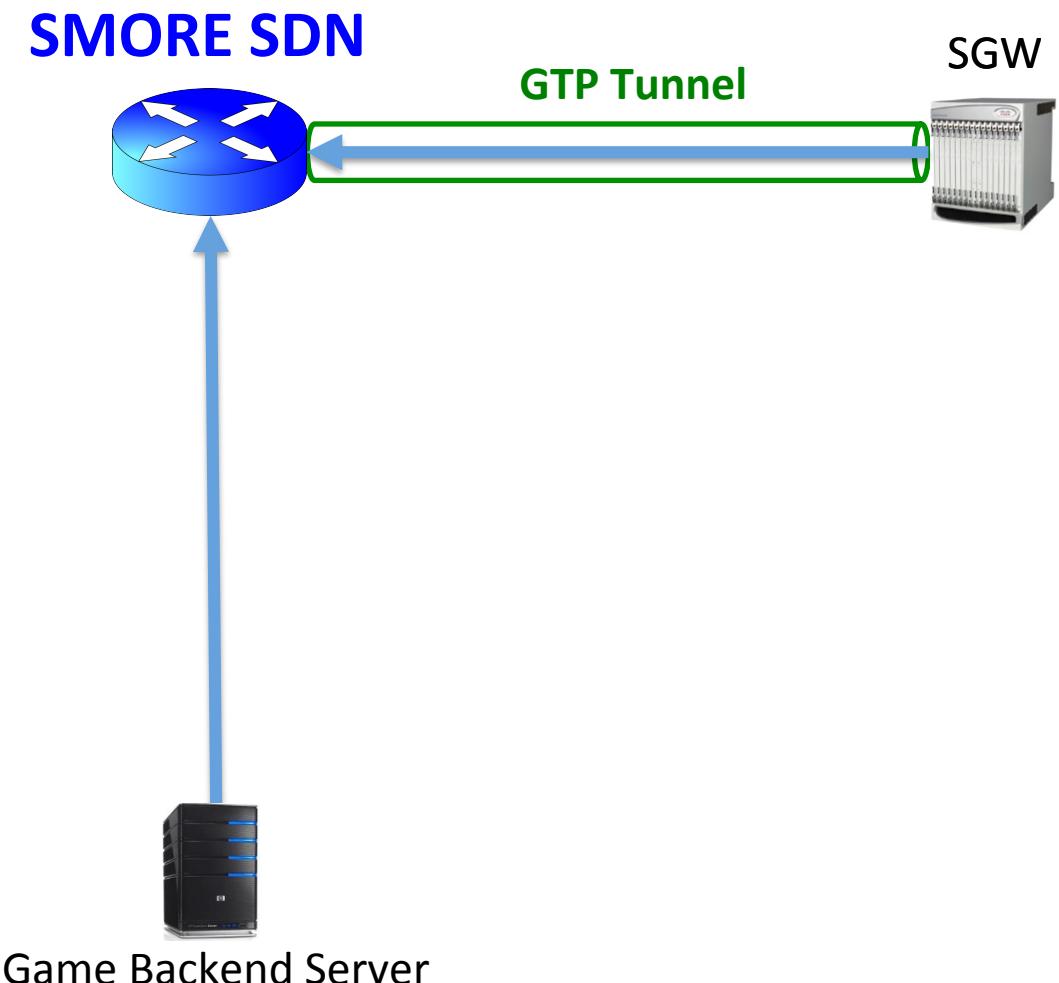
Uplink Traffic Redirection



Uplink Traffic

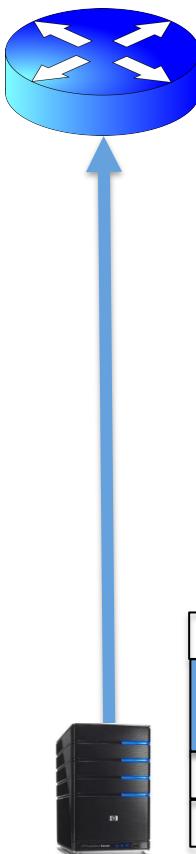


Downlink Traffic

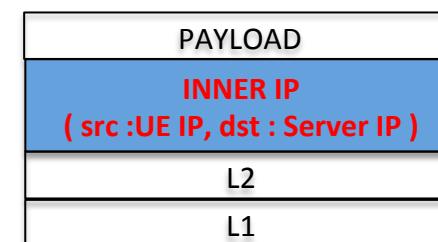


Downlink Traffic

SMORE SDN

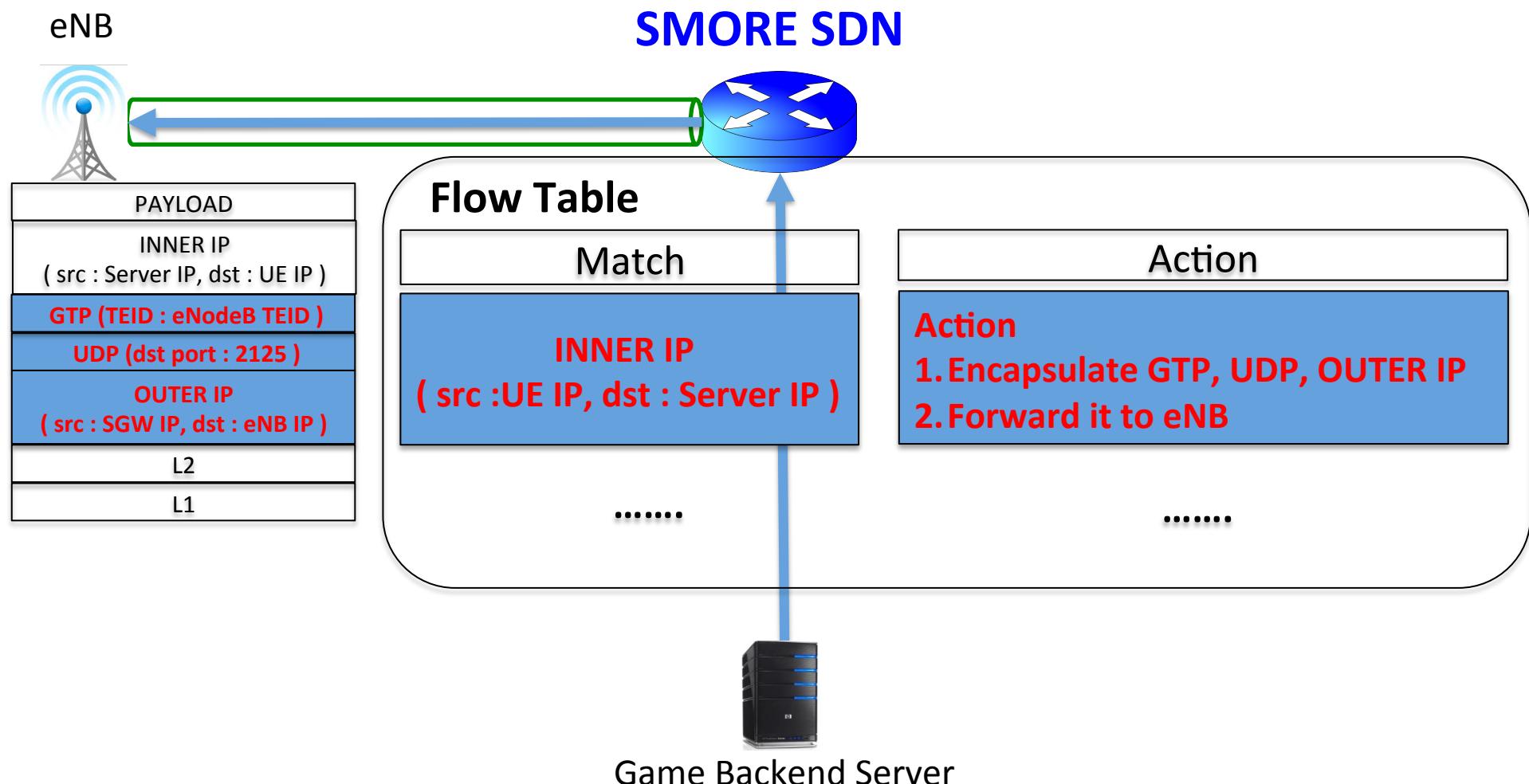


Game Backend Server

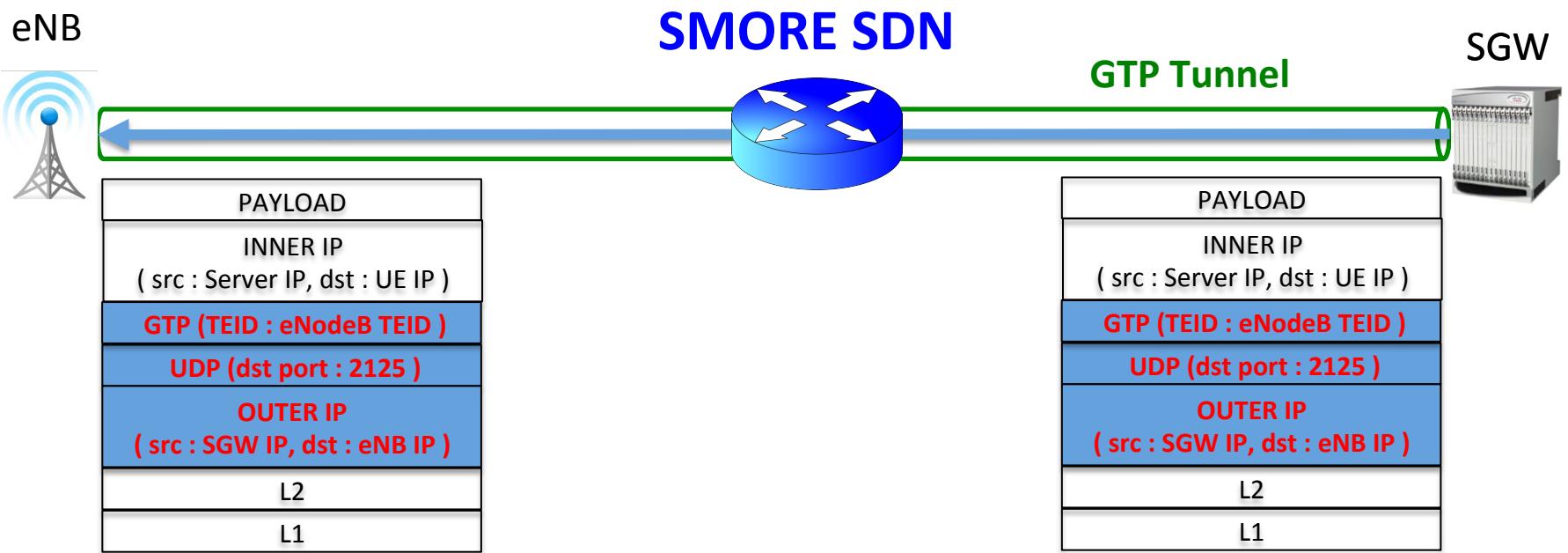


Match fields

Downlink Traffic



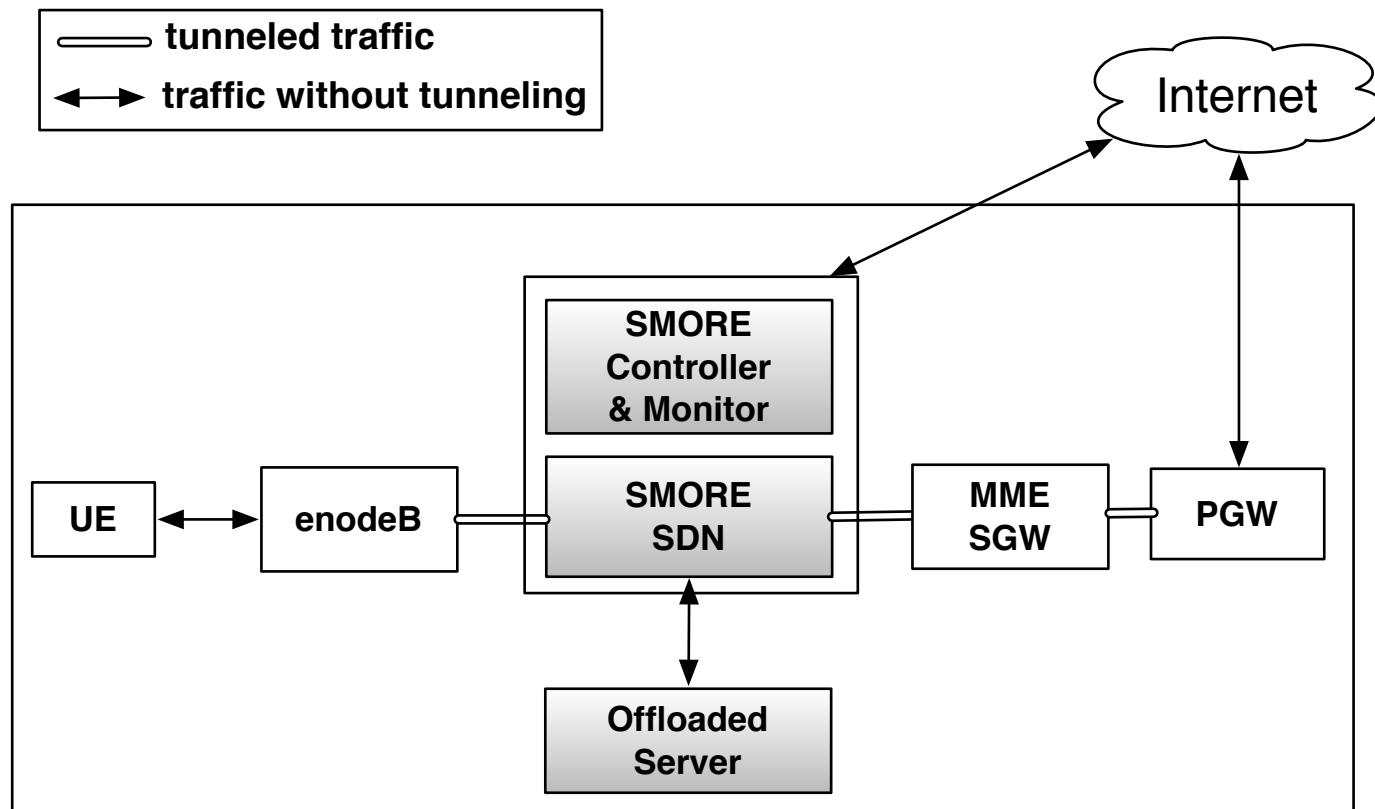
Downlink Traffic



Implementation

- LTE/EPC testbed: OpenEPC LTE/EPC software
- SMORE SDN : open Vswitch 2.0
 - Extending GTP evaluation, en/decapsulation functions by using vport abstraction mechanism
- SMORE Controller : Ryu controller
 - Extending Ryu API for GTP flow management
- SMORE Monitor : Tshark
 - Detecting attach and detach events
 - Extracting information from events and storing them to DB.

PhantomNet Testbed

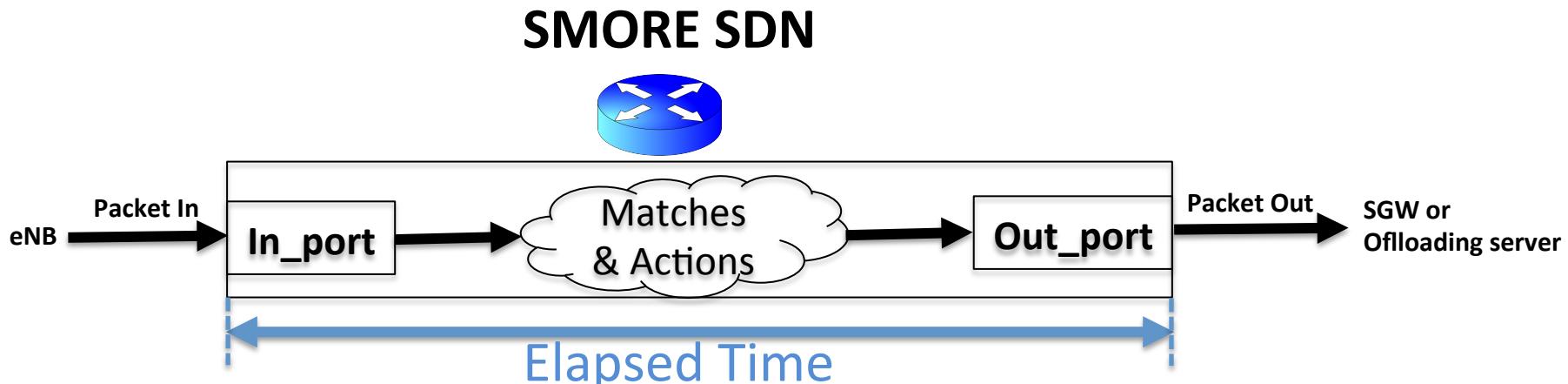


Evaluation

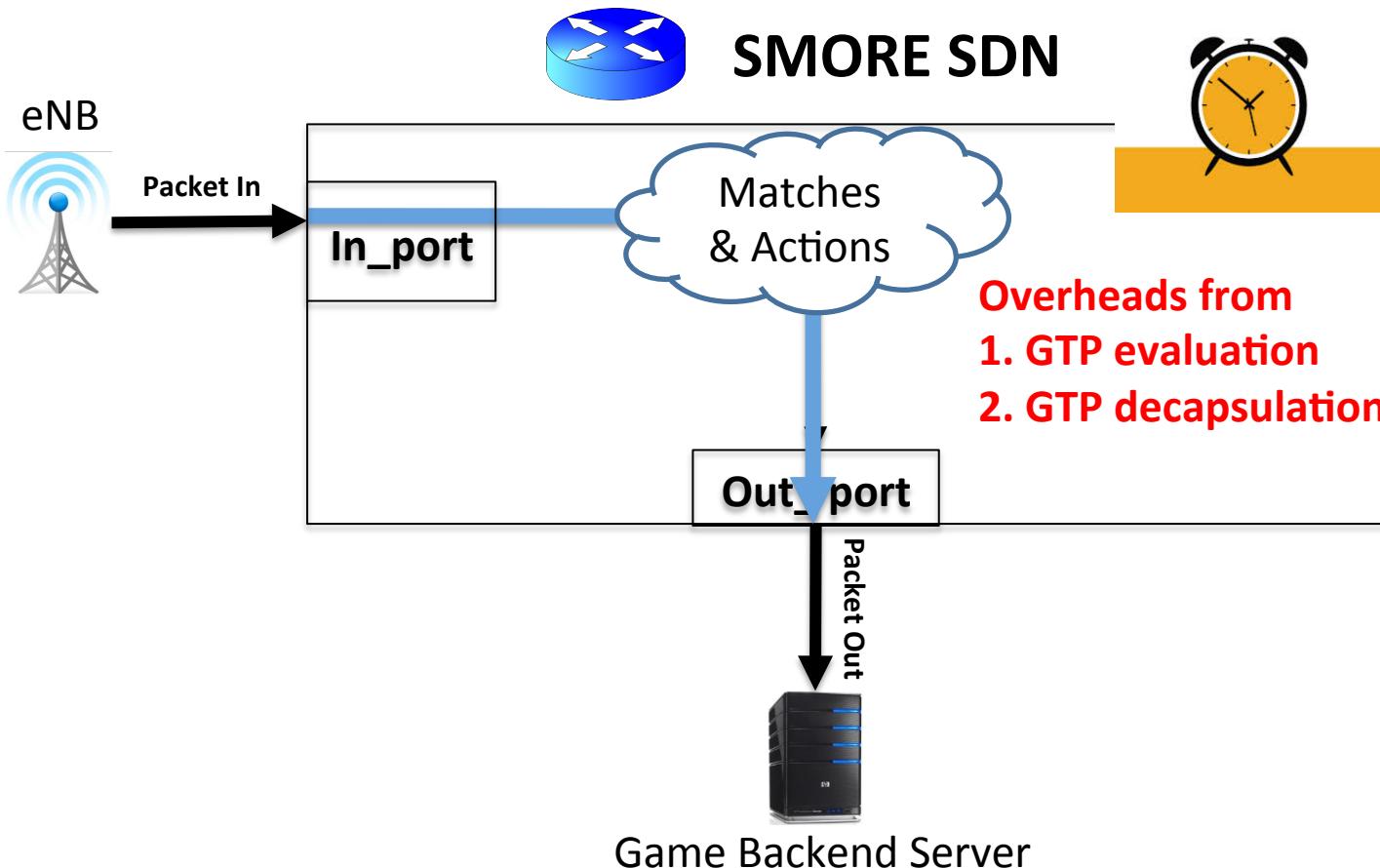
- SMORE SDN overhead
- End-to-End RTT improvement
- We use ping for evaluation

SMORE SDN Overhead

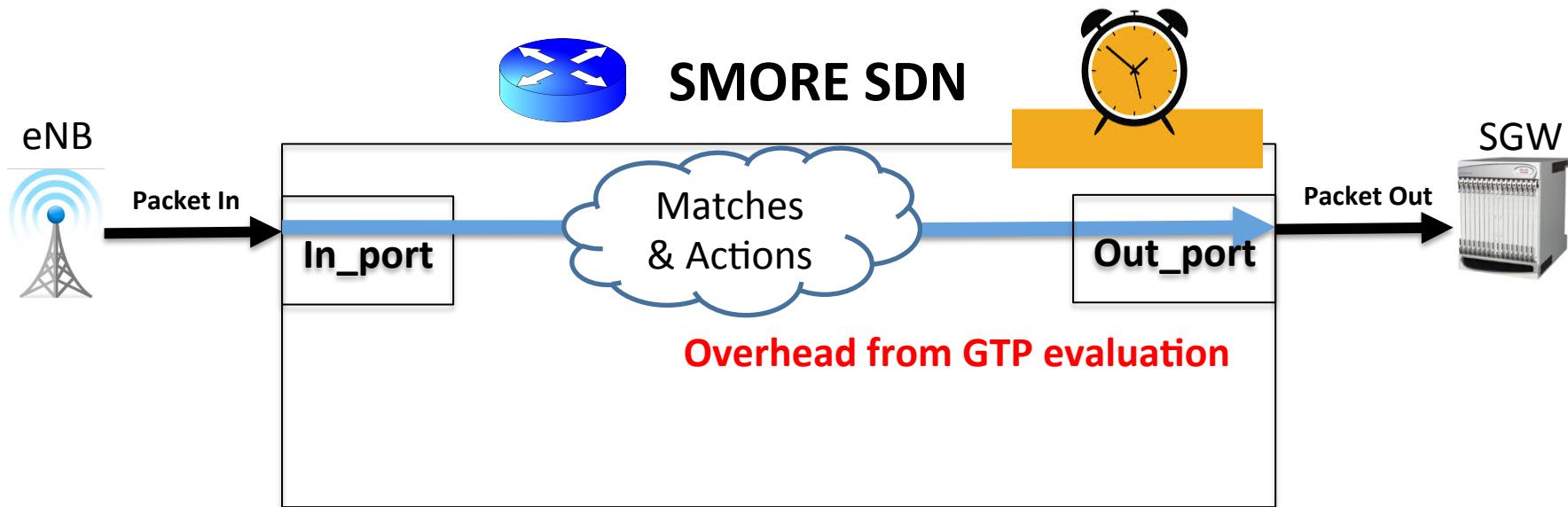
- Measure overheads from additional functionalities in SMORE SDN
 - GTP evaluation
 - GTP en/decapsulation
- Compare SMORE SDN with native open Vswitch



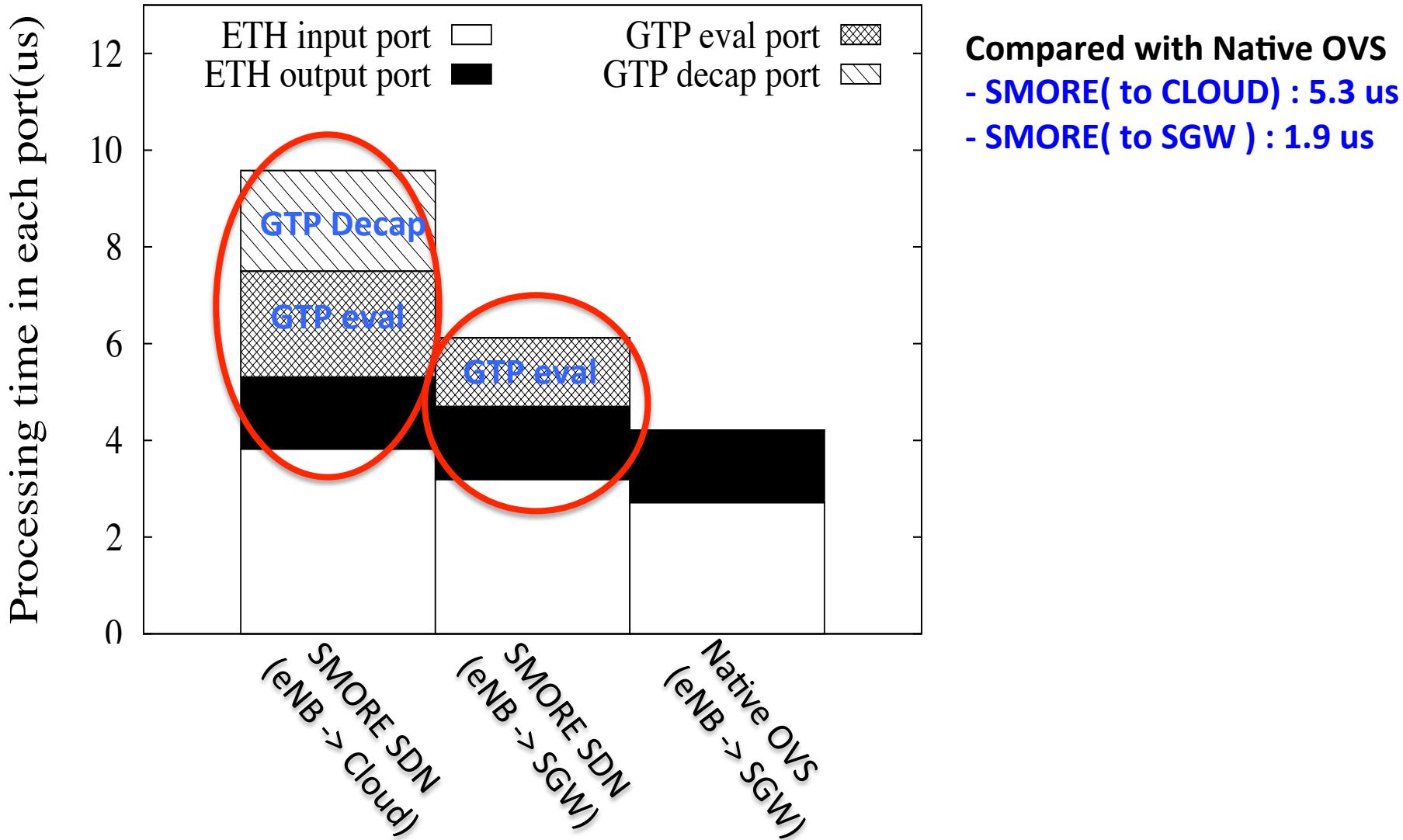
Uplink SMORE SDN Overhead



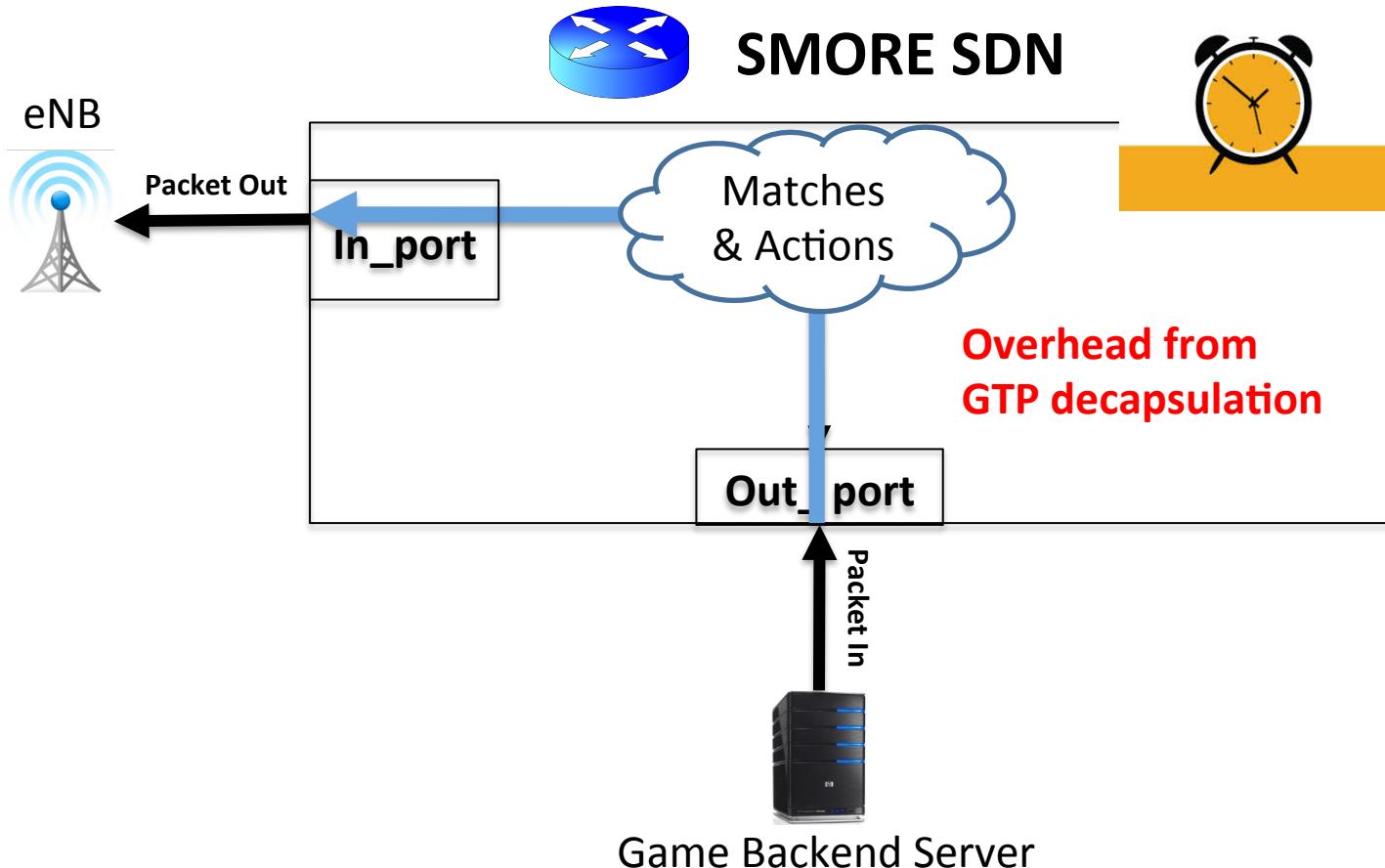
Uplink SMORE SDN Overhead



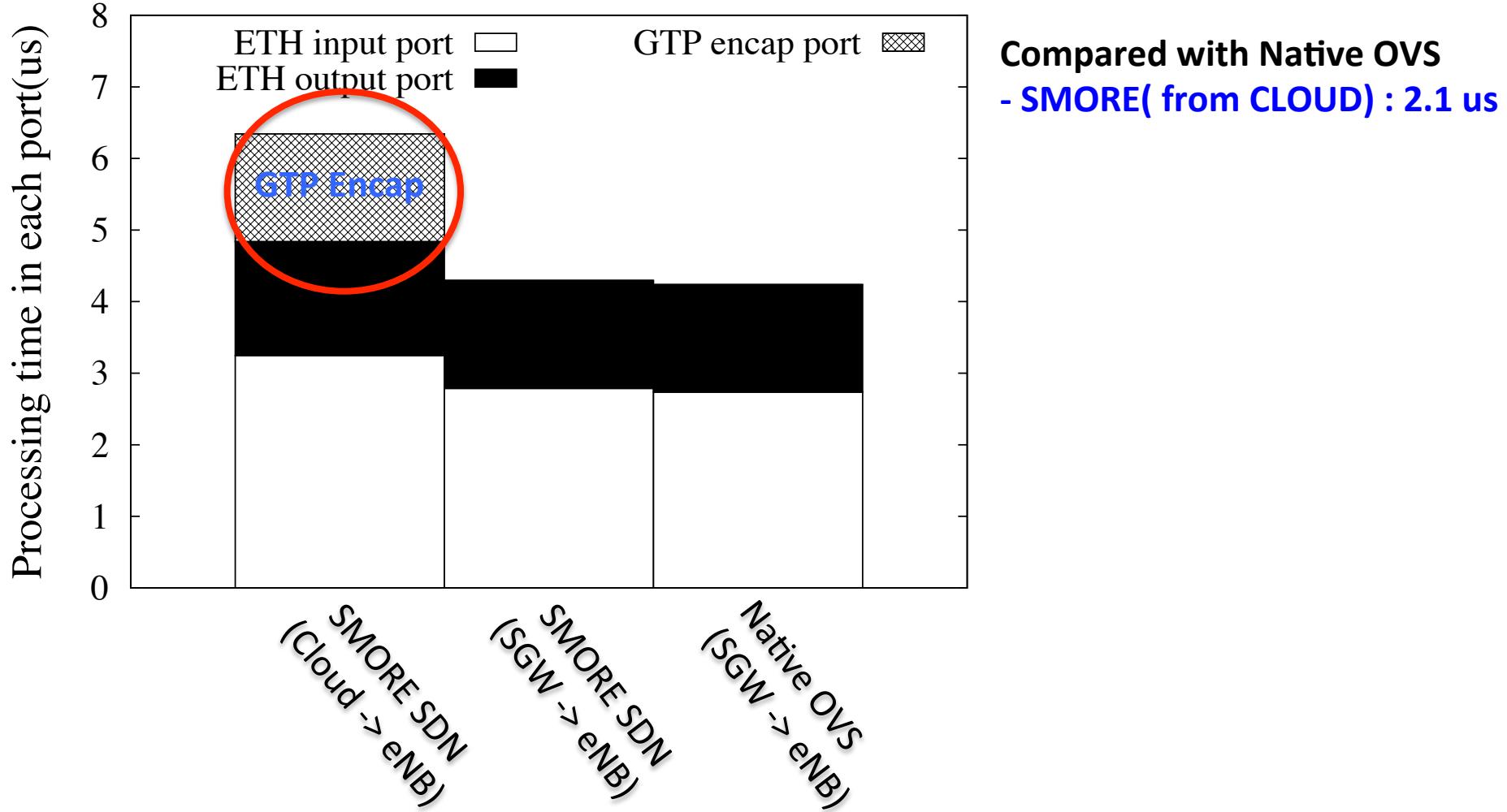
Uplink SMORE SDN Overhead



Downlink SMORE SDN Overhead



Downlink SMORE SDN Overhead



Feasibility and Limitation of SMORE

- The overall overhead due to processing GTP functionalities in SMORE SDN is not high compared to end-to-end delay in LTE (~70ms)
- May have scalability issue in SMORE SDN
 - Explore scalability in SMORE SDN
- Architectural limitation
 - Limited support for handover (supporting Intra-LTE Handover using the X2 interface)

Conclusion

- We presented SMORE architecture to realize traffic offloading to reduce end-to-end delay
 - No modification of existing LTE/EPC mobile network.
 - Show how offloading for selected traffic of subscribed users can realized even when handover happens
- Prototype realization of SMORE architecture in PhantomNet LTE/EPC testbed.

Thank you! Questions?



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