

A?

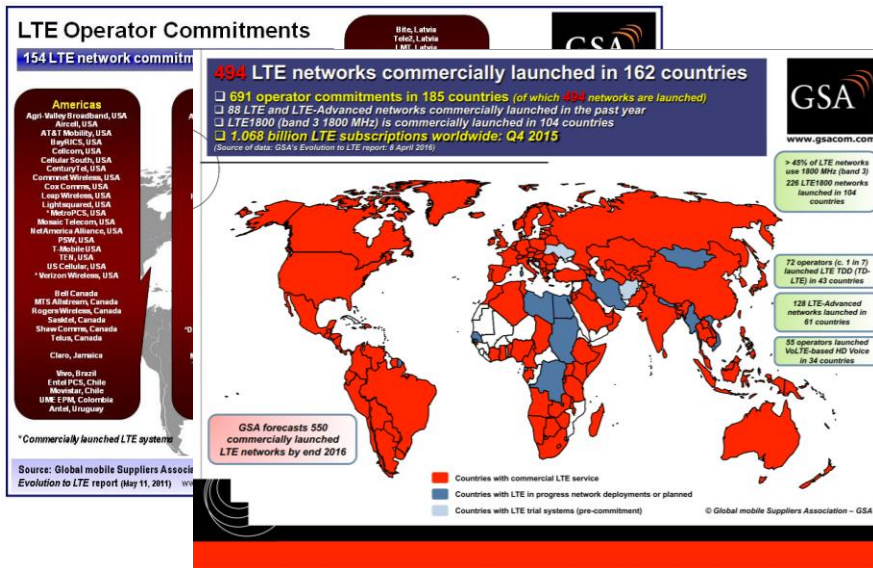
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Towards 5G: On Network Softwarization

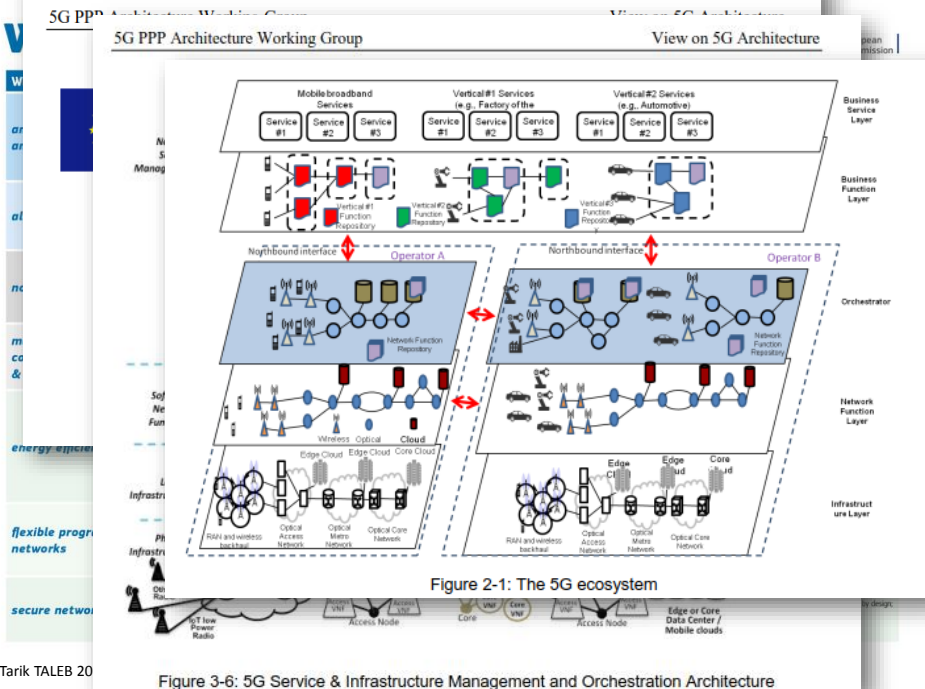
Prof. Tarik Taleb
School of Electrical Engineering
Aalto University

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Global LTE Commitments



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Requirements on 5G ...

**High data rates
everywhere**

**Very high traffic
capacity**

**Massive number of
devices**

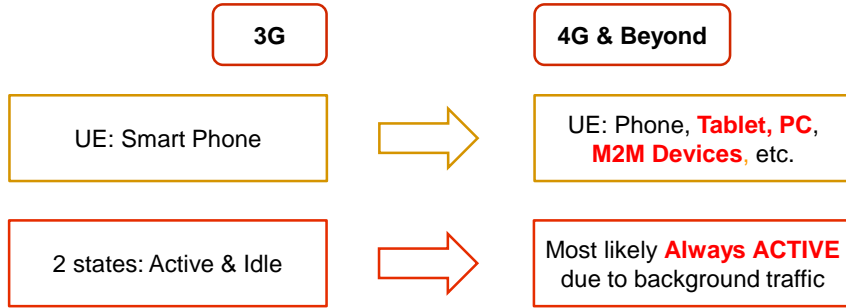
**Ultra-high
reliability & security**

**Very low device
cost**

**Very low device
energy consumption**

Very low latency

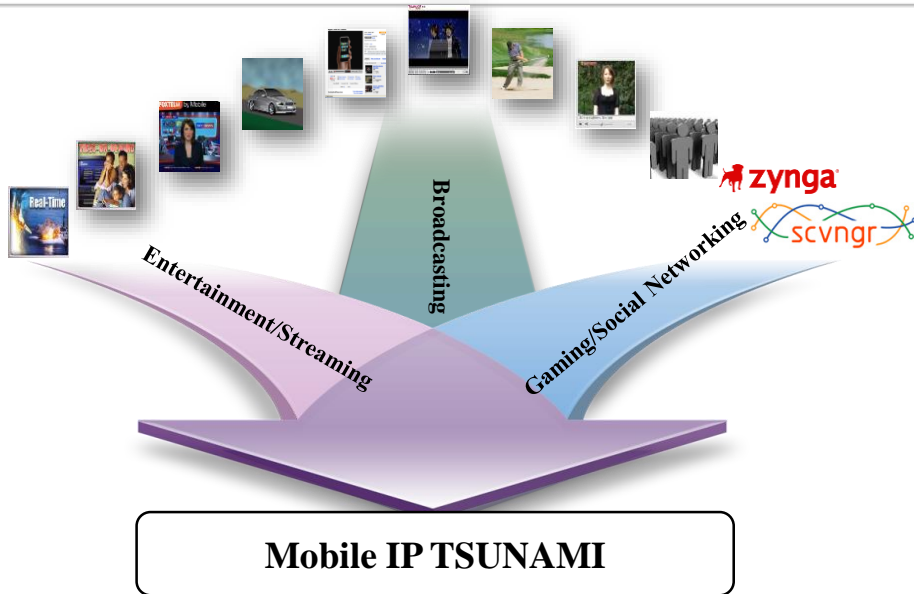
Evolution of User Equipment



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Mobile IP Tsunami?



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Solutions

Invest in Speed

- Today's backbone will be the edge!



Upgrade network nodes

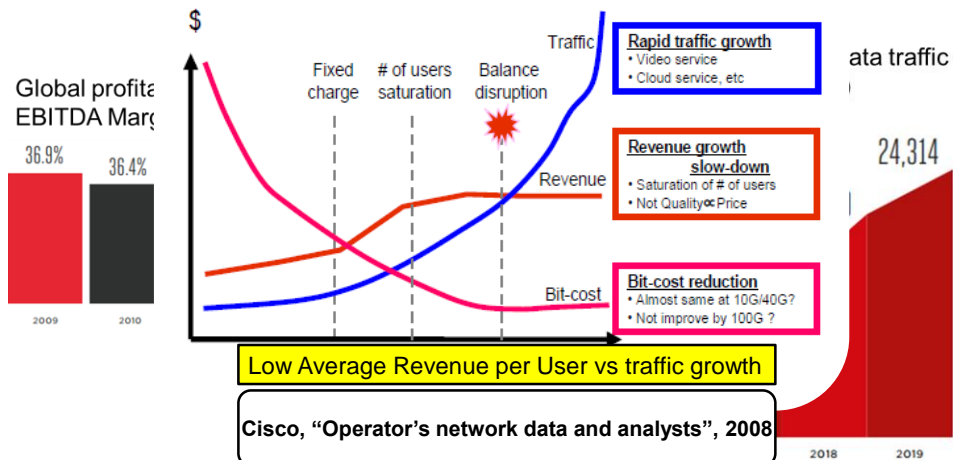
Design a scalable network

- To accommodate peak hours

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How ready are Operators to invest more?

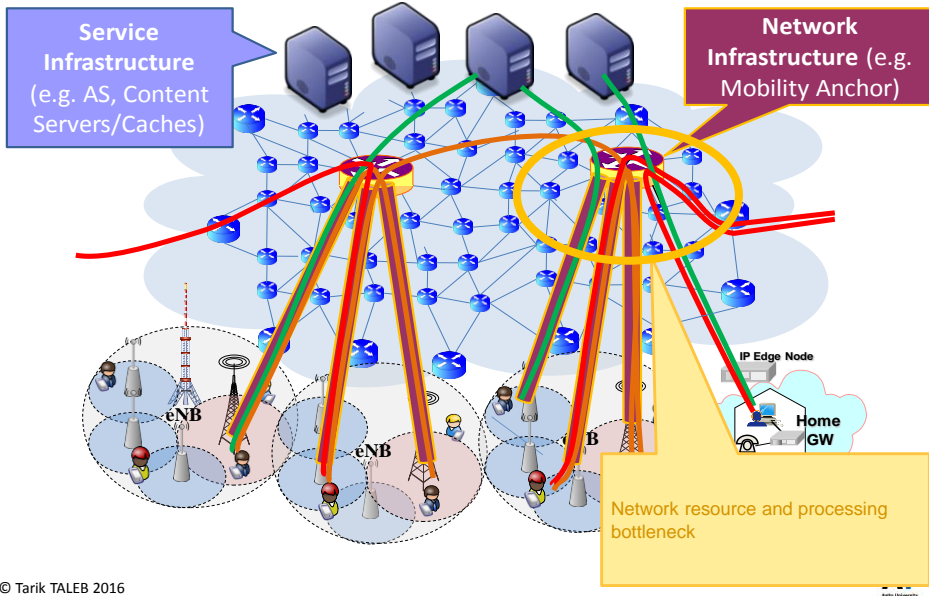


"The Mobile Economy 2015", GSMA

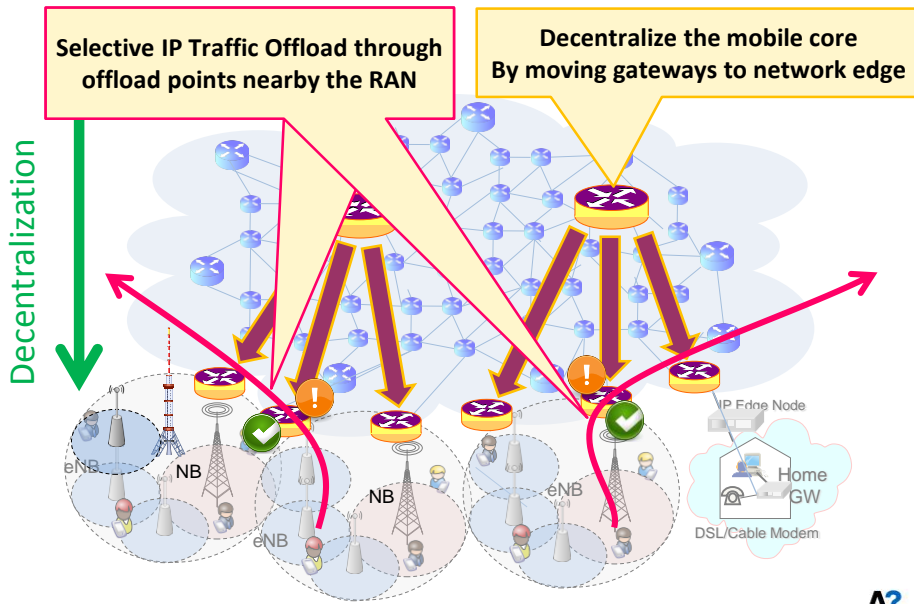
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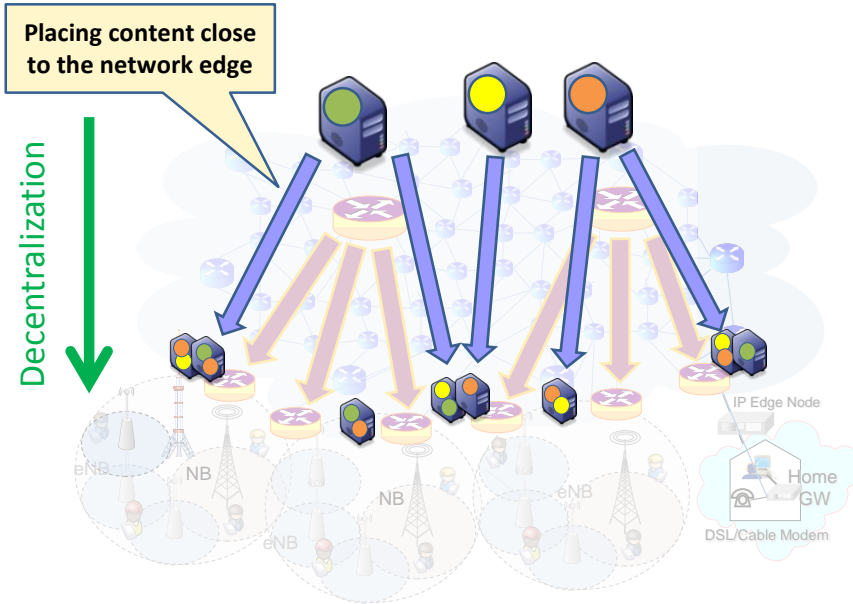
Current Mobile Operator NW Arch.



Decentralize & Offload



Build & Decentralize Mobile CDN



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Trend towards Distributed Regional DCs

Apple building super datacenters all over the world says analyst

DATA CENTER KNOWLEDGE

DATA CENTER KNOWLEDGE

Solar-Powered Micro Data Center at Rutgers

Posted By Rich Miller On May 31, 2012 @ 7:39 pm In Green Data Centers | 2 Comments

The Rutgers Computer Science Department has built a solar-powered "micro data center" comprised of a small container, a set of solar panels, a

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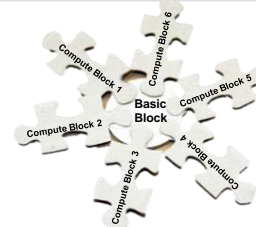


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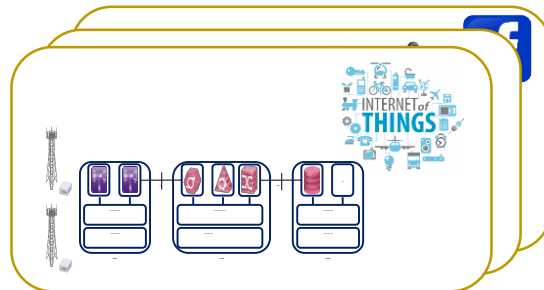
Network Softwarization

Objectives

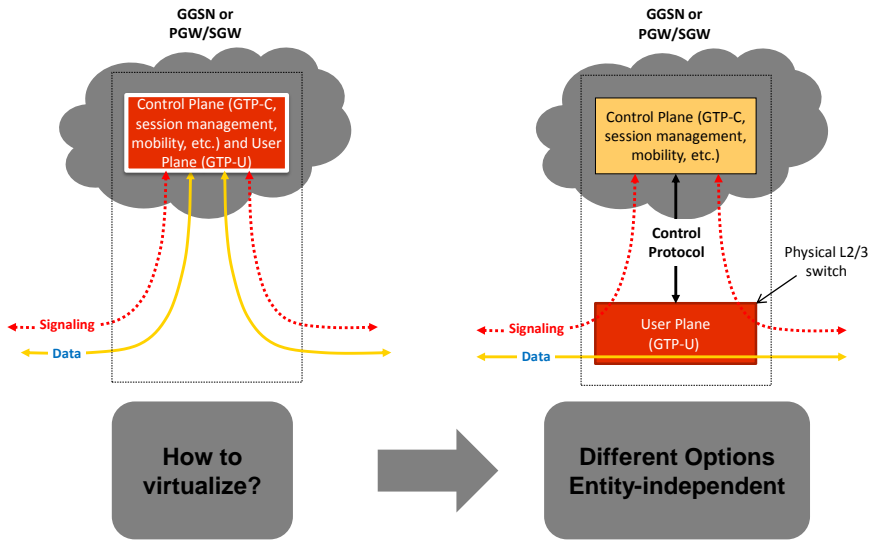
Transform mobile networks
into virtualized software
components



- Enable the creation & lifecycle management of diverse network slices for different verticals



What to Virtualize: Full vs Partial Virtualization



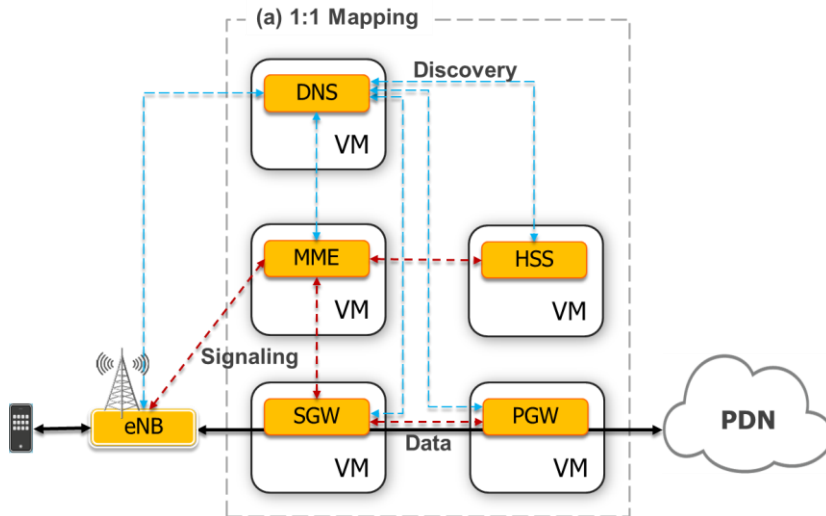
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T. Taleb, M. Corici, C. Parada, A. Jamakovic, S. Ruffino, G. Karagiannis, and T. Magedanz, "EASE: EPC as a Service to Ease Mobile Core Network," in IEEE Network Magazine, Vol. 29, No. 2, Mar. 2015, pp.78 - 88.



EPCaaS Architecture Options

1:1 Mapping



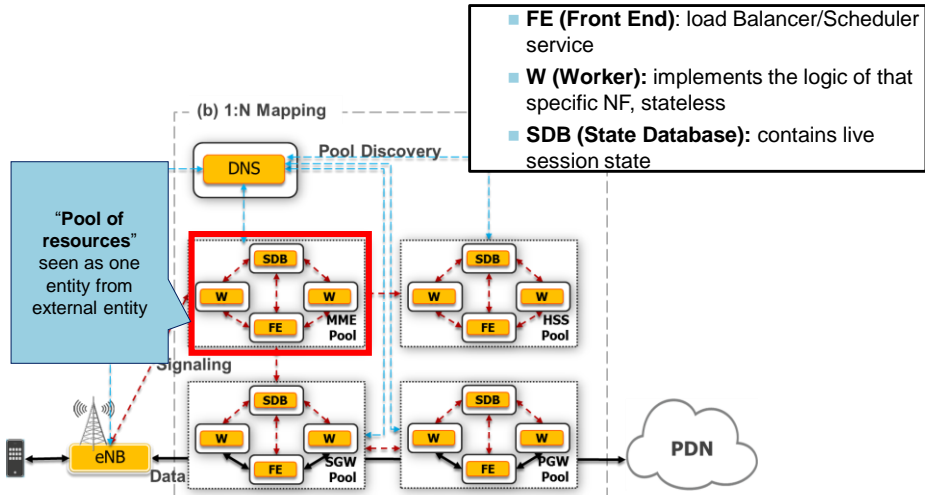
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T. Taleb, M. Corici, C. Parada, A. Jamakovic, S. Ruffino, G. Karagiannis, and T. Magedanz, "EASE: EPC as a Service to Ease Mobile Core Network," in IEEE Network Magazine, Vol. 29, No. 2, Mar. 2015, pp.78 - 88.



EPCaaS Architecture Options

1:N Mapping



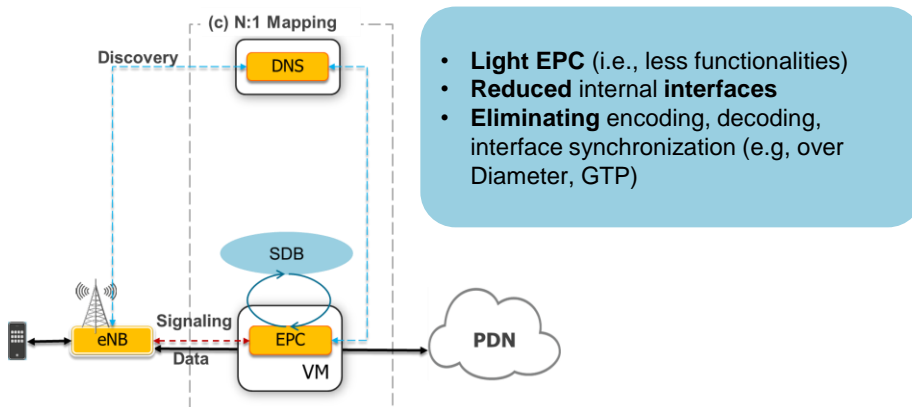
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T. Taleb, M. Corici, C. Parada, A. Jamakovic, S. Ruffino, G. Karagiannis, and T. Magedanz, “EASE: EPC as a Service to Ease Mobile Core Network,” in IEEE Network Magazine, Vol. 29, No. 2, Mar. 2015, pp.78 - 88.



EPCaaS Architecture Options

N:1 Mapping



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T. Taleb, M. Corici, C. Parada, A. Jamakovic, S. Ruffino, G. Karagiannis, and T. Magedanz, “EASE: EPC as a Service to Ease Mobile Core Network,” in IEEE Network Magazine, Vol. 29, No. 2, Mar. 2015, pp.78 - 88.

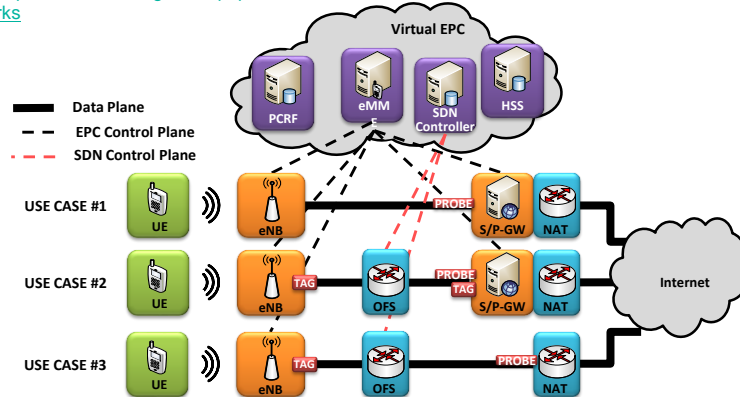


Aalto Contribution to Standardisation

ETSI PoC based on SIGMONA testbed submitted in cooperation with Nokia, Coriant, EXFO and Telecom Italia.

Objectives:

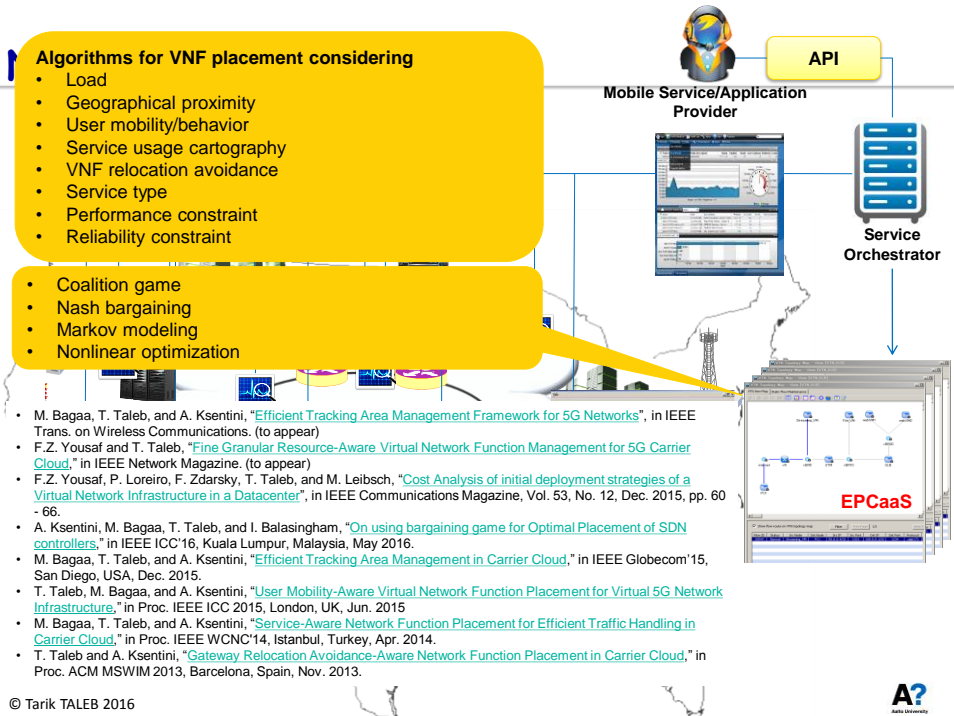
- Integration of SDN and NFV functions in mobile backhaul
- Show with off the shelf devices (Nokia eNBs, Coriant MPLS switches, EXFO Monitoring) the mobility and network adaptation during congestion or link breaks
- [http://nfvwiki.etsi.org/index.php?title=Virtual_EPC_with_SDN_Function_in_Mobile_Backhaul Networks](http://nfvwiki.etsi.org/index.php?title=Virtual_EPC_with_SDN_Function_in_Mobile_Backhaul_Networks)



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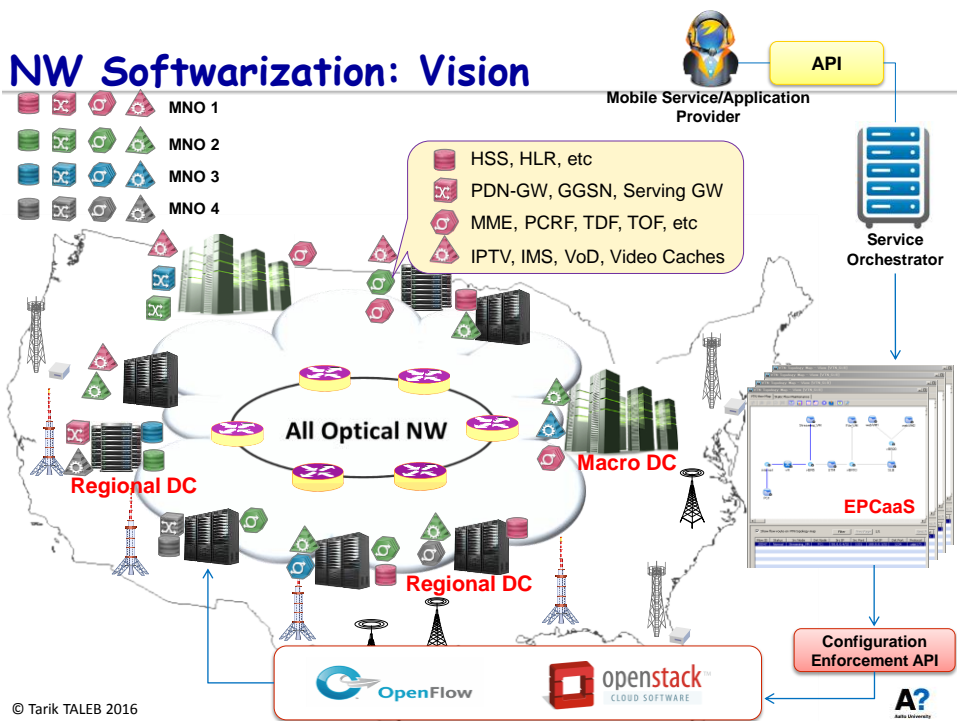
**NW Softwarization:
System Orchestration**



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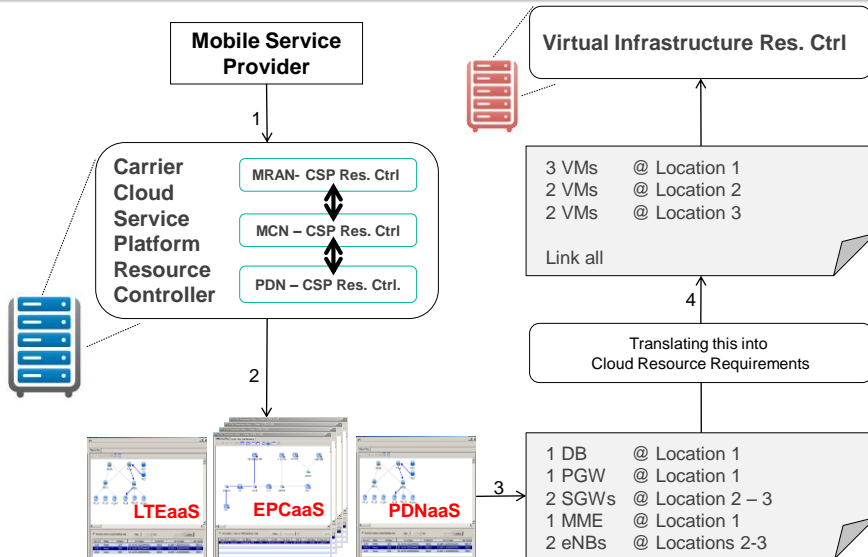
NW Softwarization: Vision



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NW Softwarization - Step by Step 1/2

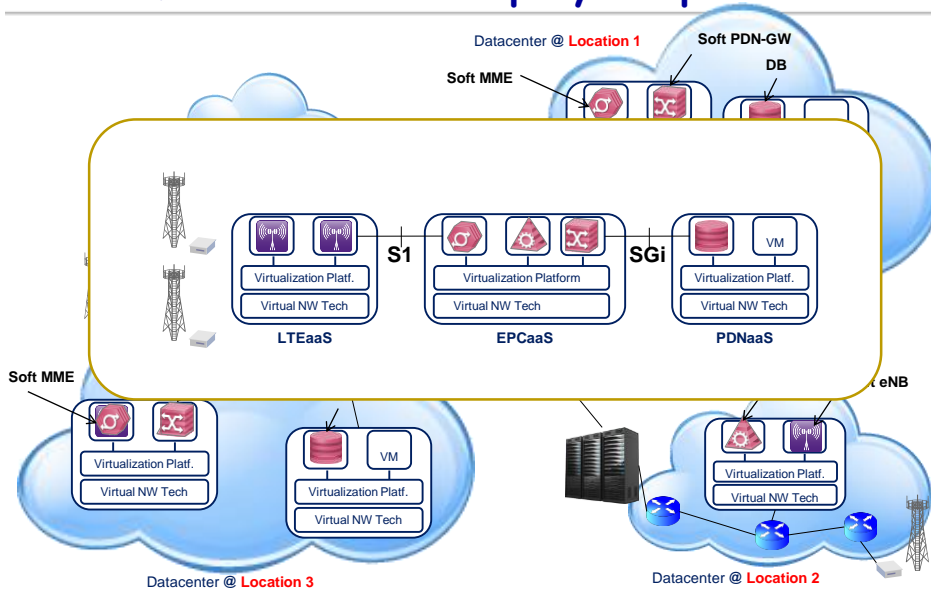


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T. Taleb, "Towards Carrier Cloud: Potential, Challenges, & Solutions," in IEEE Wireless Communications Magazine, Vol. 21, No. 3, Jun. 2014. pp. 80-91.



NW Softwarization - Step by Step 2/2

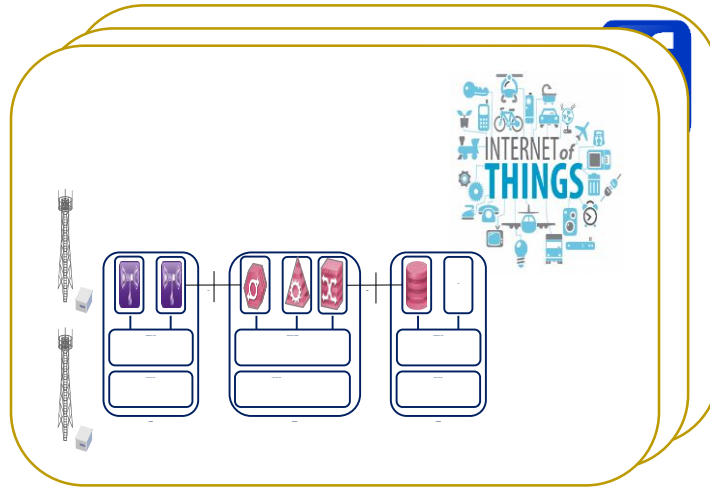


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T. Taleb, "Towards Carrier Cloud: Potential, Challenges, & Solutions," in IEEE Wireless Communications Magazine, Vol. 21, No. 3, Jun. 2014. pp. 80-91.



NW Softwarization: A NW slice for every mobile service



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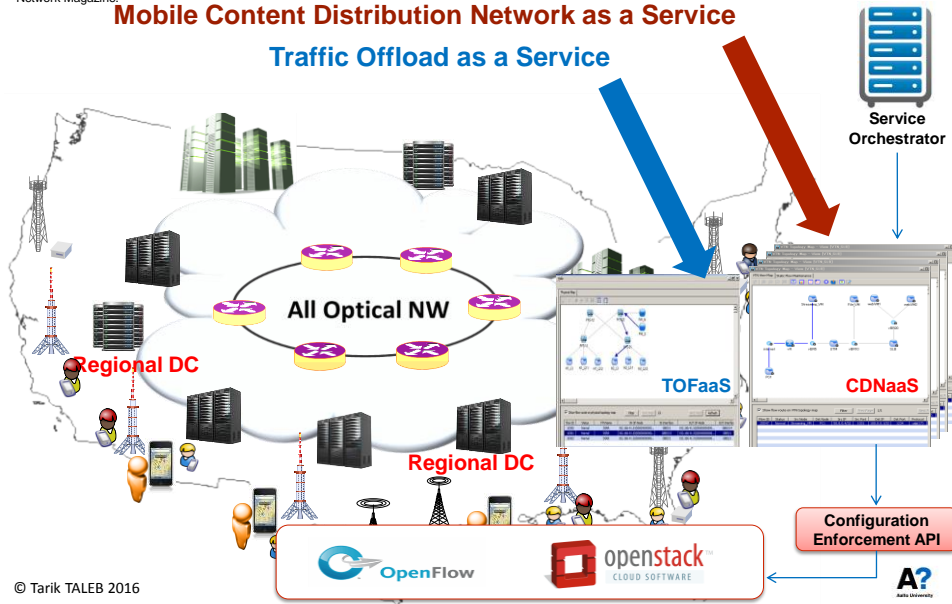
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virtual Mobile CDN on the Fly

Mobile vCDN on the fly 2/3

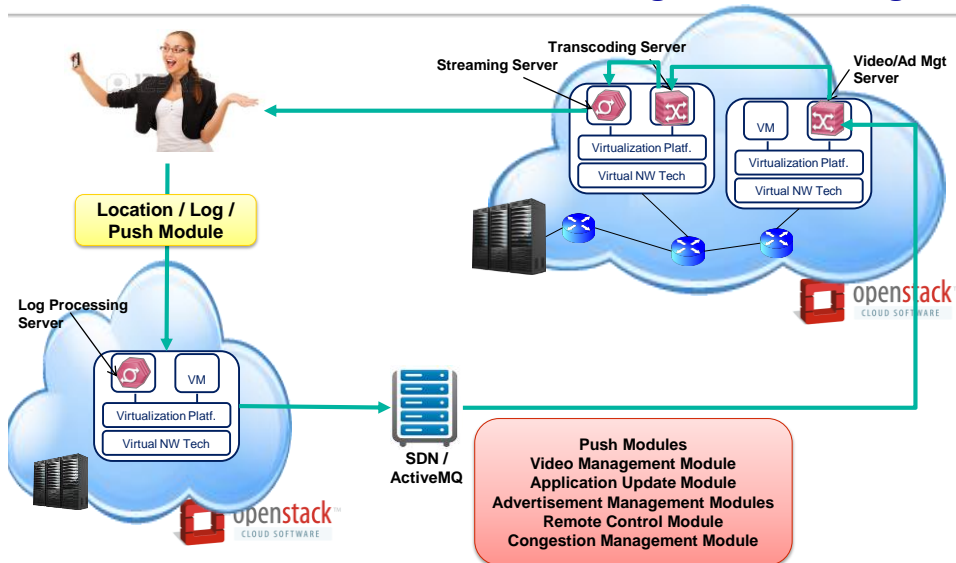
T. Taleb, A. Ksentini, and R. Jantti, "Anything as a Service for 5G Mobile Systems", in IEEE Network Magazine.

Mobile Content Distribution Network as a Service Traffic Offload as a Service



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Cloud Based Multimedia Transcoding & Streaming

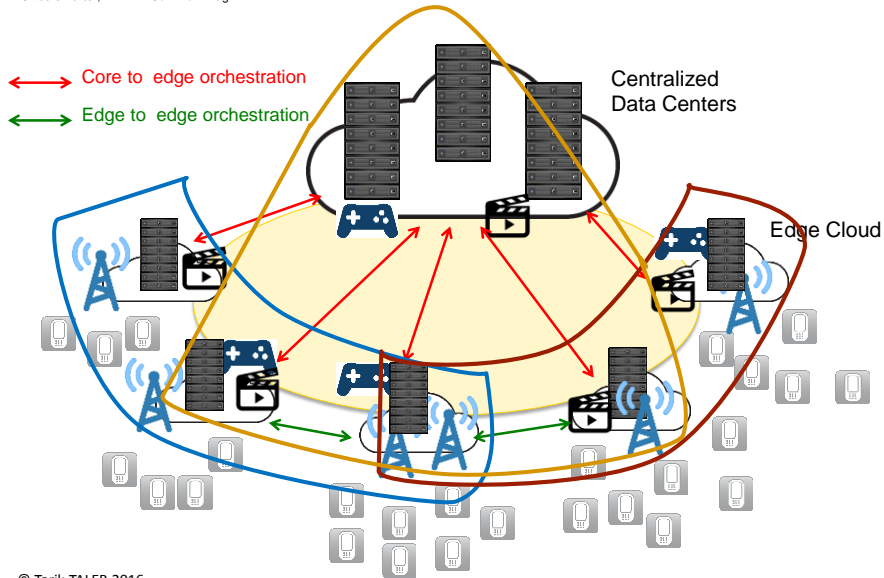


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CDN at the Edge

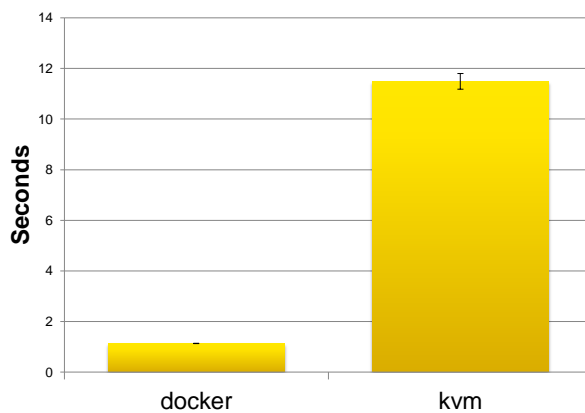
T. Taleb, S. Dutta, A. Ksentini, and M. Iqbal, "Mobile Edge Computing Potential in Making Cities Smarter," in IEEE Commun. Mag.



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VNF Performance in Virtual Environments: NGINX HTTP Server - Startup Times

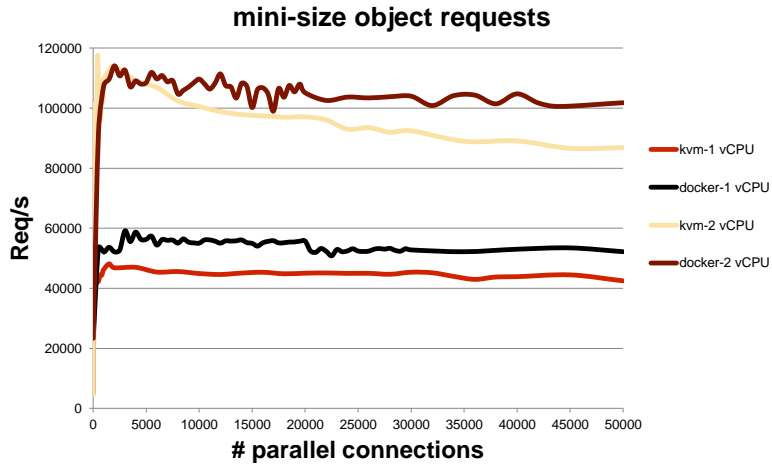


P. Frangoudis, L. Yala, A. Ksentini, and T. Taleb, "An architecture for on-demand service deployment over a telco CDN," in IEEE ICC'16, Kuala Lumpur, Malaysia, May 2016.

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VNF Performance in Virtual Environments: NGINX HTTP Server - HTTP Request Throughput

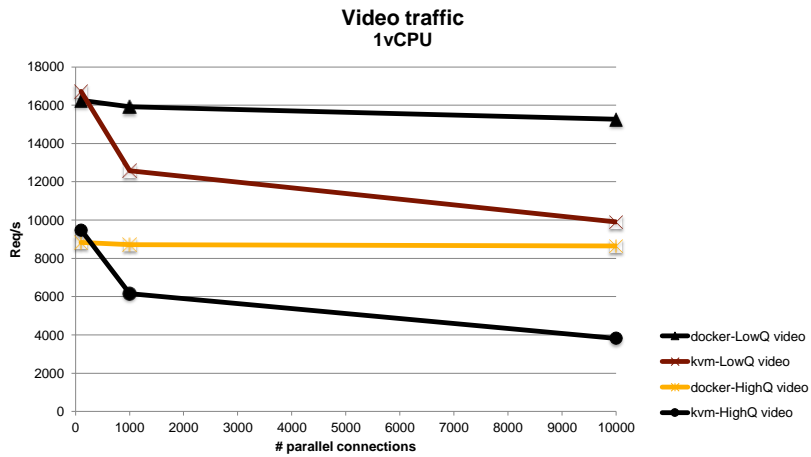


P. Frangoudis, L. Yala, A. Ksentini, and T. Taleb, "An architecture for on-demand service deployment over a telco CDN," in IEEE ICC'16, Kuala Lumpur, Malaysia, May 2016.

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VNF Performance in Virtual Environments: NGINX HTTP Server - HTTP Request Throughput

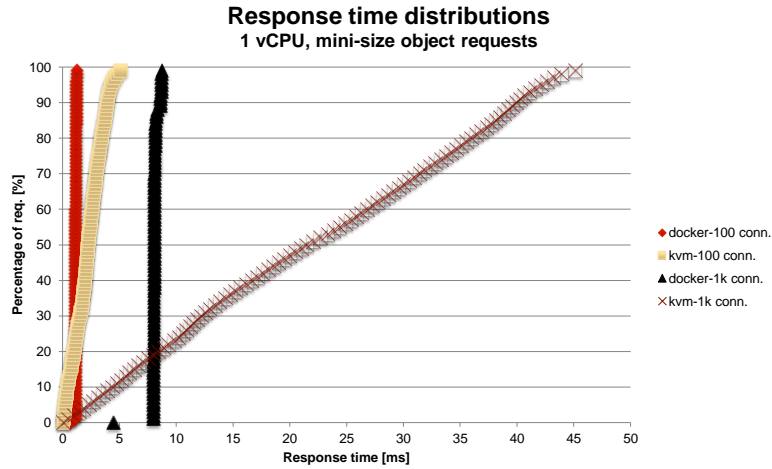


P. Frangoudis, L. Yala, A. Ksentini, and T. Taleb, "An architecture for on-demand service deployment over a telco CDN," in IEEE ICC'16, Kuala Lumpur, Malaysia, May 2016.

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VNF Performance in Virtual Environments: NGINX HTTP Server - Response Time

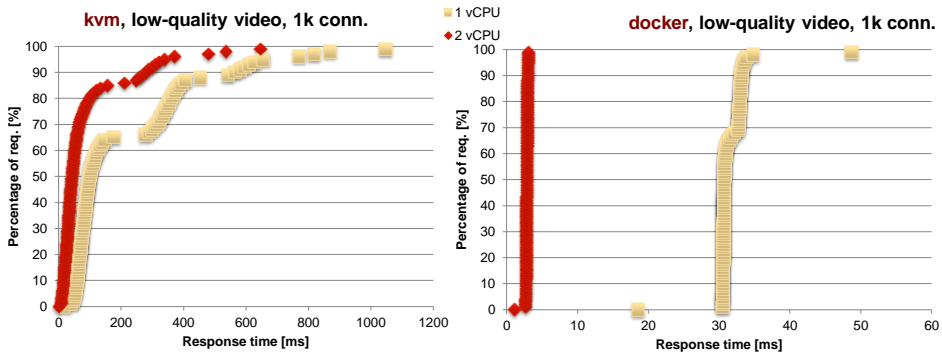


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T. Taleb, A. Ksentini, and R. Jantti, "Anything as a Service for 5G Mobile Systems;" to appear in IEEE Network Magazine.



VNF Performance in Virtual Environments: NGINX HTTP Server - Response Time Distribution



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T. Taleb, A. Ksentini, and R. Jantti, "Anything as a Service for 5G Mobile Systems;" to appear in IEEE Network Magazine.



Enabling Technologies



EU-Japan Collaboration Project Proposal

5G!Pagoda

"A network slice for every service"

5G! PAGODA

Federating Japanese and European 5G Testbeds to Explore Relevant Standards and Align Views on 5G Mobile Network Infrastructure Supporting Dynamic Creation and Management of Network Slices for Different Mobile Services.

サービスに応じたスライス動的生成・管理機能の実証と標準化を目的とする日欧連携 5G 移動通信基盤テストベッド

Call: EUJ1-2016 - 5G - Next Generation Communication Networks
Coordinators: Tarik Taleb and Akihiro Nakao
E-mails: tarik.taleb@aalto.fi and nakao@nakao-lab.org
Phone: +358-50-435-2325 and +81-3-5841-2384



Fraunhofer
FOKUS



HITACHI



Conclusion

5G

- Requirements: Elasticity, flexibility, agility, short latency!
- Cloud potential

Network Sotwarization / Mobile Cloud Networking

- Many advantages to offer
- Key enabling technologies
 - NFV
 - SDN
- Yet many challenges to tackle

Use Case: vCDN on the fly

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Relevant J. Papers

- M. Bagaa, **T. Taleb**, and A. Ksentini, "Efficient Tracking Area Management Framework for 5G Networks", in **IEEE Trans. on Wireless Communications**. (to appear)
- **T. Taleb**, A. Ksentini, and R. Jantti, "Anything as a Service for 5G Mobile Systems", in **IEEE Network Magazine**. (to appear)
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- A. Ksentini, **T. Taleb**, and K. Benlelaief, "QoE-based Flow Admission Control in Small Cell Networks", in **IEEE Trans. on Wireless Communications**. (to appear)
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- **T. Taleb**, A. Ksentini, and B. Sericola, "On Service Resilience in Cloud-Native 5G Mobile Systems", in **IEEE J. Select. Areas in Communications**. (to appear)
- F.Z. Yousaf and **T. Taleb**, "Fine Granular Resource-Aware Virtual Network Function Management for 5G Carrier Cloud," in **IEEE Network Magazine**. (to appear)
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- **T. Taleb**, M. Corici, C. Parada, A. Jamakovic, S. Ruffino, G. Karagiannis, and T. Magedanz, "EASE: EPC as a Service to Ease Mobile Core Network," in **IEEE Network Magazine**, Vol. 29, No. 2, Mar. 2015, pp.78 - 88.
- **T. Taleb** and A. Ksentini, "VECOS: A Vehicular Connection Steering Protocol," in **IEEE TRANS. on Vehicular Technology**, Vol. 64, No. 3, Mar. 2015, pp. 1171 - 1187
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- A. Ksentini, **T. Taleb**, and F. Messaoudi, "A LISP-based Implementation of Follow Me Cloud," in **IEEE Access Magazine**, Vol 2, Oct. 2014, pp. 1340-1347
- **T. Taleb**, K. Samdanis, and A. Ksentini, "Supporting Highly Mobile Users in Cost-Effective Decentralized Mobile Operator Networks," in **IEEE Trans. on Vehicular Technology**, Vol. 63, No. 7, Sep. 2014, pp. 3381-3396.
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- **T. Taleb** and A. Ksentini, "Follow Me Cloud: Interworking Federated Clouds & Distributed Mobile Networks", in **IEEE Network Magazine**, Vol. 27, No. 5, Sep./Oct. 2013, pp. 12 - 19

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Relevant Conf. Papers

- P. Frangoudis, L. Yala, A. Ksentini, and **T. Taleb**, "An architecture for on-demand service deployment over a telco CDN," in **IEEE ICC'16**, Kuala Lumpur, Malaysia, May 2016.
- A. Ksentini, M. Bagaa, **T. Taleb**, and I. Balasingham, "On using bargaining game for Optimal Placement of SDN controllers," in **IEEE ICC'16**, Kuala Lumpur, Malaysia, May 2016.
- S. Dutta, **T. Taleb**, and A. Ksentini, "QoE-aware Elasticity Support in Cloud-Native 5G Systems," in **IEEE ICC'16**, Kuala Lumpur, Malaysia, May 2016.
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- G. Karagiannis, A. Jamakovic, K. Briggs, M. Karimzadeh, C. Parada, M. Corici, T. Taleb, A. Edmonds, and T.M. Bohnert, "Mobility and Bandwidth prediction in virtualized LTE systems: architecture and challenges," in Proc. **European Conf. on Networks and Communications (EUCNC)**, Bologna, Italy, Jun. 2014
- A. Ksentini, **T. Taleb** and M. Chen, "A Markov Decision Process-based Service Migration Procedure for Follow Me Cloud," in Proc. **IEEE ICC 2014**, Sydney, Australia, Jun. 2014.
- M. Bagaa, **T. Taleb**, and A. Ksentini, "Service-Aware Network Function Placement for Efficient Traffic Handling in Carrier Cloud," in Proc. **IEEE WCNC'14**, Istanbul, Turkey, Apr. 2014.
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- **T. Taleb**, P. Hasselmeier, and F. Mir, "Follow-Me Cloud: An OpenFlow-based Implementation," in Proc. **IEEE GreenCom'13**, Beijing, China, Aug. 2013.
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- **T. Taleb**, K. Samdanis, and S. Schmid, "DNS-based Solution for Operator Control of Selected IP Traffic Offload," in Proc. **IEEE ICC**, Kyoto, Japan, Jun. 2011.

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