### MME - FAAS

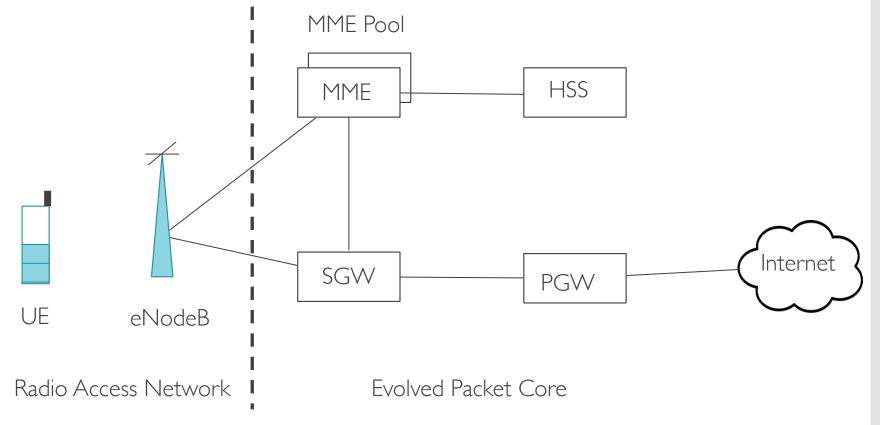
Cloud-Native Control for Mobile Networks

Sonika Jindal, Robert Ricci

University of Utah

Nov 21, 2019

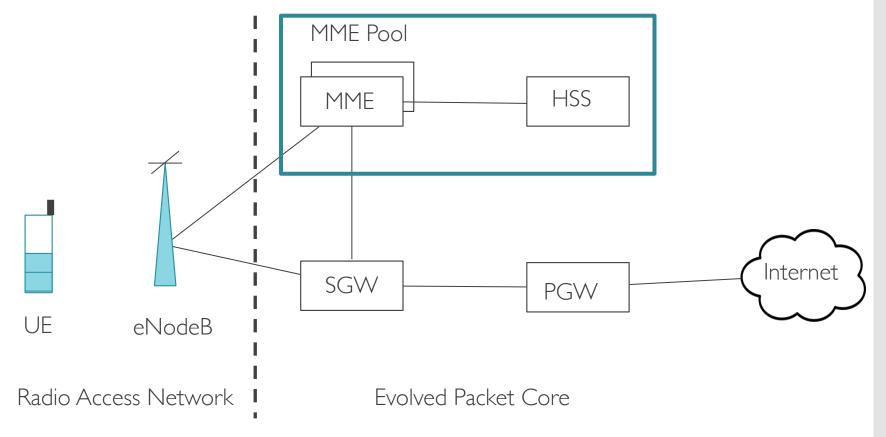
# Introduction – Mobile network architecture



In the US, 400M Subscribers, 200K Cell towers, 50 MME Pool, 2.7M UE per MME

[https://www.statisticbrain.com/ cell-phone-tower-statistics/]
[https://en.wikipedia.org/wiki/List\_of\_United\_States\_wireless\_ communications\_service\_providers ]
[Mohammadkhan, A., Ramakrishnan, K. K., Rajan, A. S., and Maciocco, C. Considerations for Re-designing the Cellular Infrastructure Exploiting Software-based Networks. 2016, ICNP) ]

# Introduction – Mobile network architecture

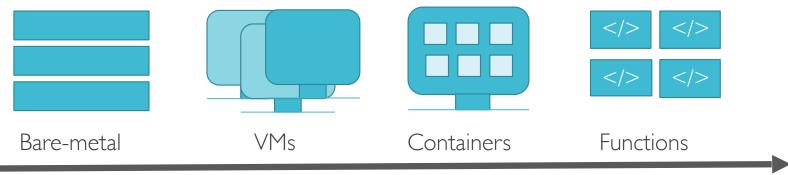


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#### Introduction – Serverless & FaaS

- Managed Services
- Auto provisioning
- Function as a Service
- Platform to develop, run and manage functionality
- Event-driven functions

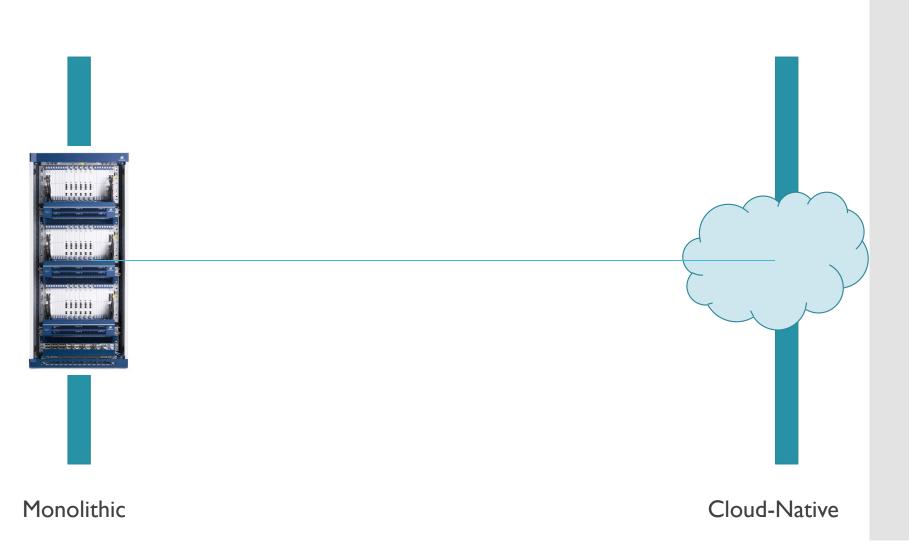


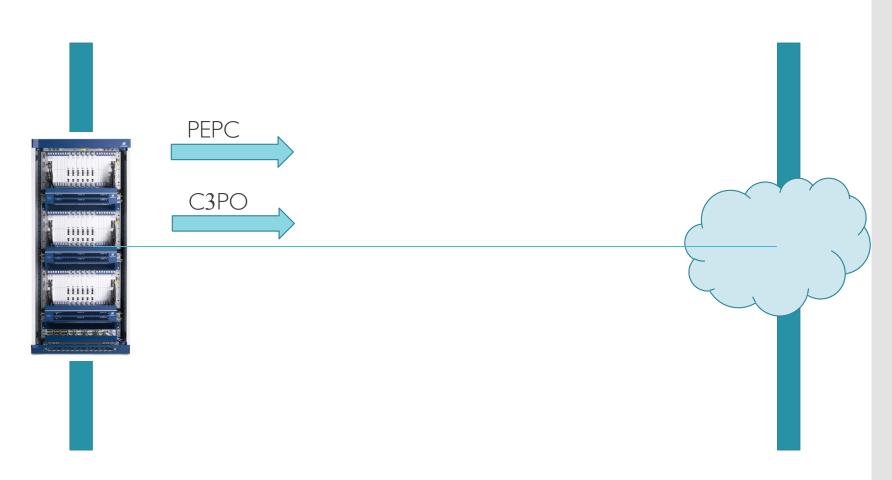
Level of Abstraction

# Mapping Mobile core to Serverless

Mobile Core Challenges	Serverless Feature
Purpose-built hardware	Software components
Over-provisioning	Dynamic allocation
Slow and costly capacity changes	Dynamic scaling
Monolithic Application	Independently scalable elements
Expensive	Pay-per-use

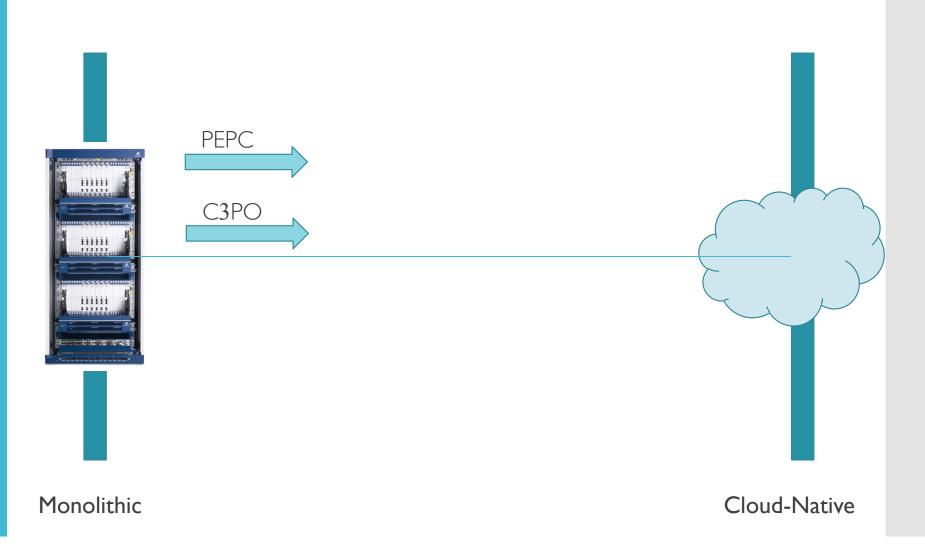
MME model using FaaS without 3GPP compliance

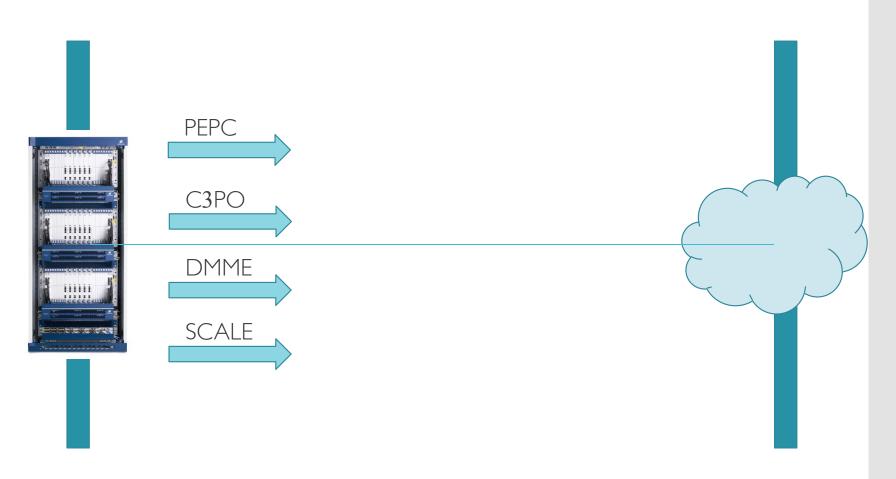




Monolithic Cloud-Native

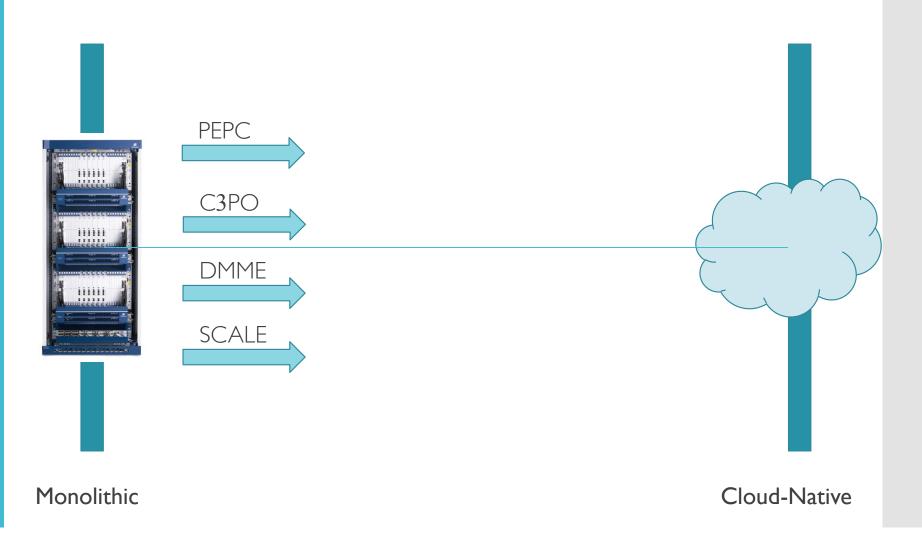
[Qazi, Z. A., Walls, M., Panda, A., Sekar, V., Ratnasamy, S., Shenker, S SIGCOMM '17] [Sprint, Intel Labs collaboration project]

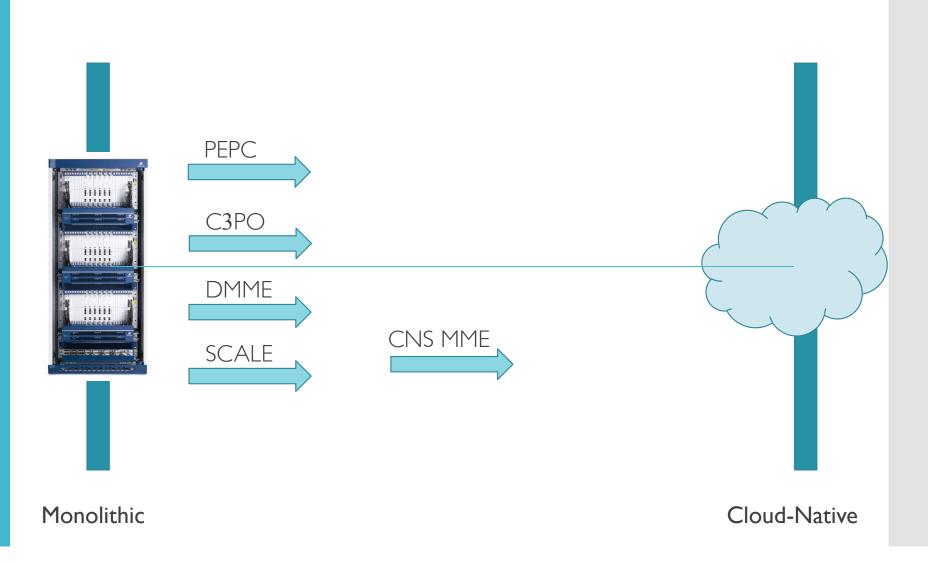


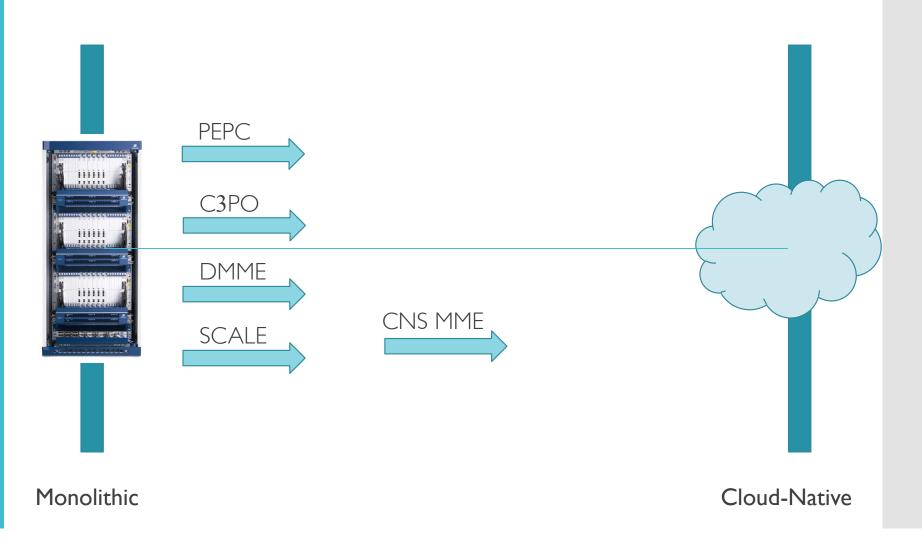


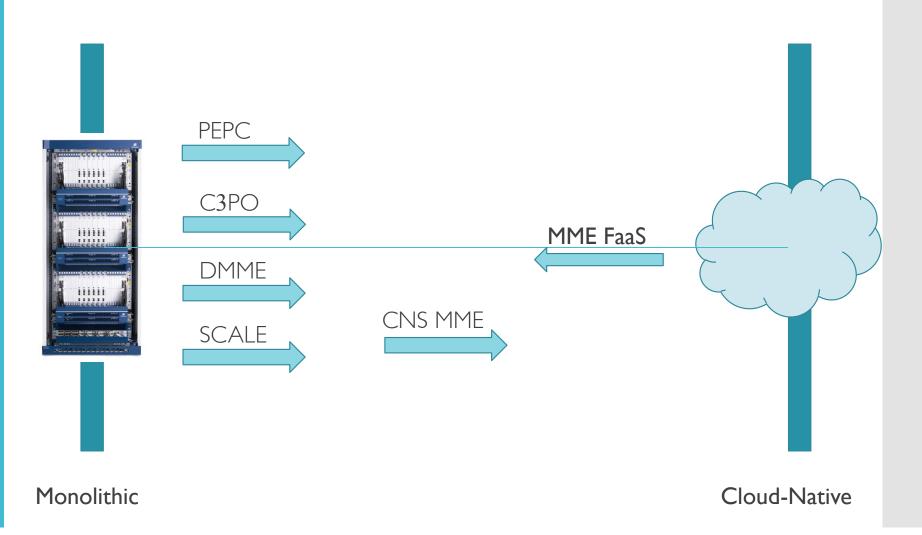
Monolithic Cloud-Native

[An, X., Pianese, F., Widjaja, I., and Acer, U. G. Bell Labs Technical Journal 17] [Banerjee, A., Mahindra, R., Sundaresan, K., Kasera, S., Van der Merwe, K., and Rangarajan, S CoNEXT '15]

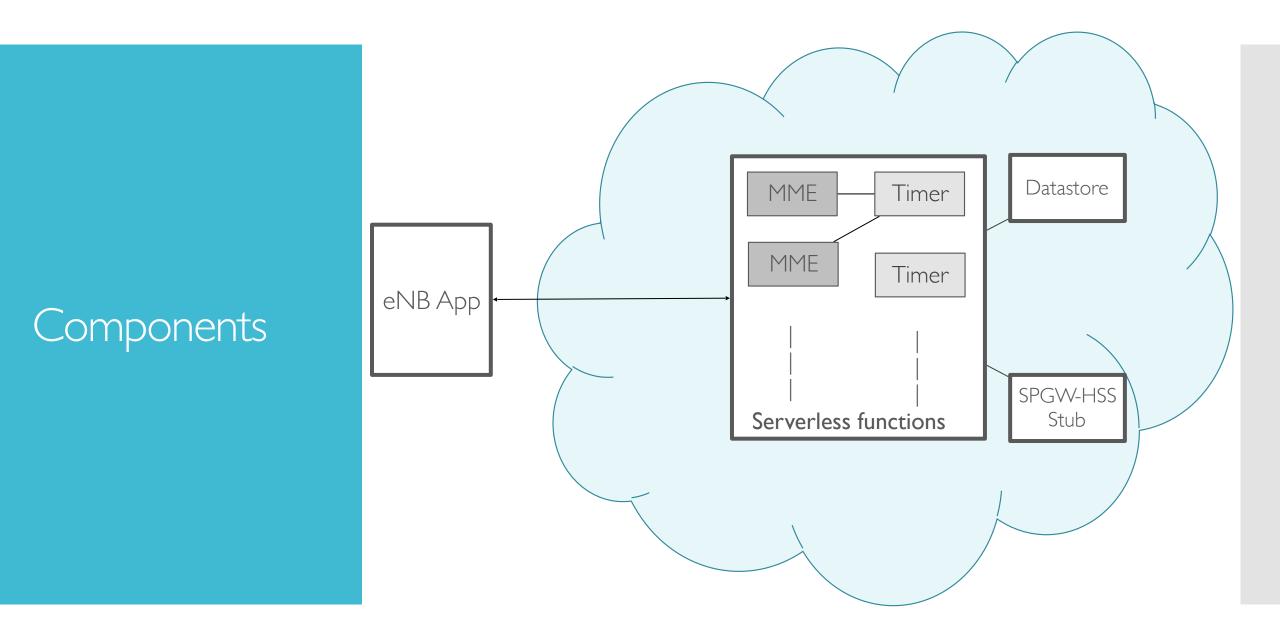




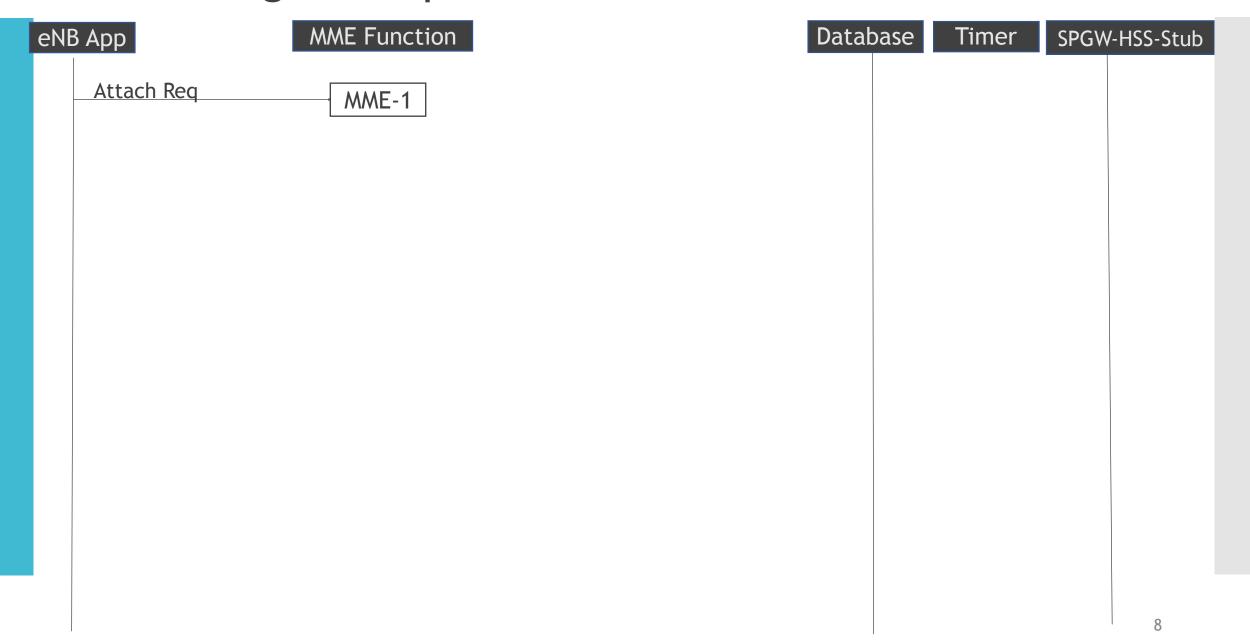




## Details



eNB App	MME Function	Da	atabase	Timer	SPGW-HSS-Stub	
					8	



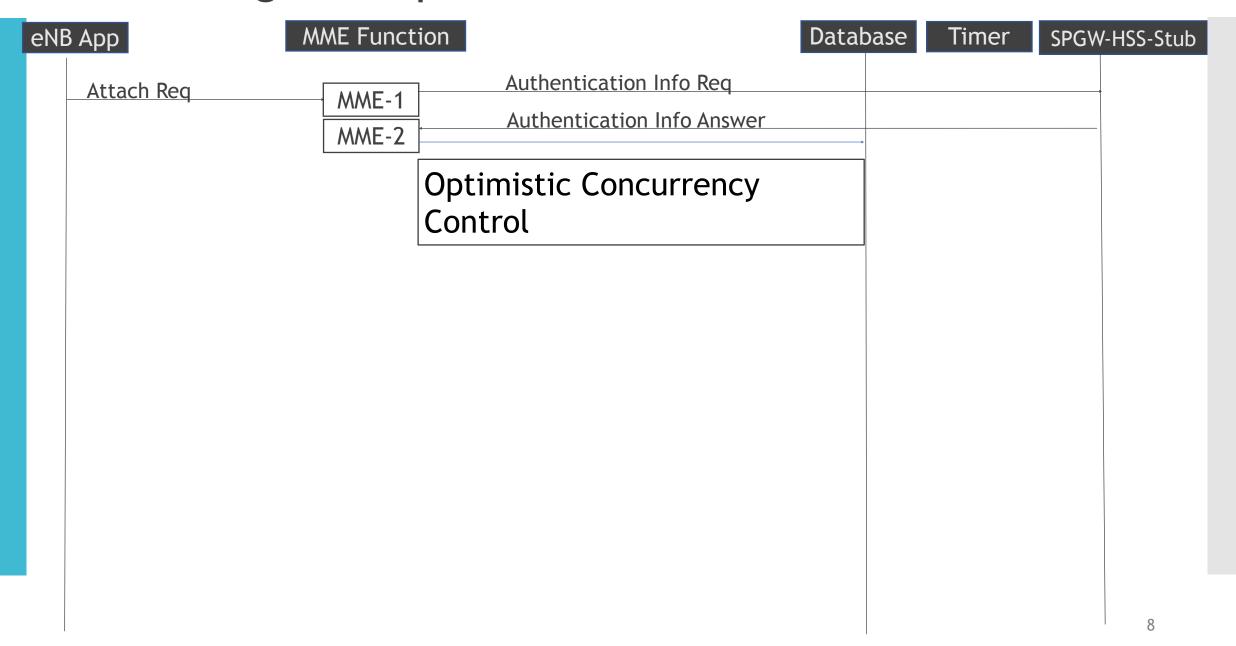
eNE	В Арр	MME Function		Database	Timer S	PGW-HSS-Stub
	Attach Req	MME-1	Authentication Info Req			
						8

eNB App	MME Function		Database Time	er SPGW-HSS-Stub
Attach Req	MME-1 MME-2	Authentication Info Req Authentication Info Answer		
				8

eN	В Арр	MME Function		Database	Timer	SPGW-HSS-Stub
	Attach Req	MME-1  MME-2	Authentication Info Req Authentication Info Answer  Asynchronous Response			
						8

eNB App	MME Function		Database Time	er SPGW-HSS-Stub
Attach Req	MME-1 MME-2	Authentication Info Req Authentication Info Answer		
				8

eN	В Арр	MME Function		Database	Timer SPC	GW-HSS-Stub
	Attach Req	MME-1  MME-2	Authentication Info Req Authentication Info Answer			
						8



eN	В Арр	MME Function		Database	Timer SPC	GW-HSS-Stub
	Attach Req	MME-1  MME-2	Authentication Info Req Authentication Info Answer			
						8

eNB App MME Fu	nction	Database Timer	SPGW-HSS-Stub
Attach Req MME	Authentication Info Req		
. Authentication Request MME	2 Authentication Info Answer	<b>—————————————————————————————————————</b>	
			8

eNB App MME Function		Database Time	er SPGW-HSS-Stub
Attach Req MME-1	Authentication Info Req Authentication Info Answer		
Authentication Request MME-2	/ deficite detail in a / til swell	-	
Authentication Response, MME-3			
Security Mode Command		<b>-</b>	
			8

eNE	S App M	ME Function		Database	Timer	SPGW-HSS-Stub
	Attach Req  Authentication Request  Authentication Response		Authentication Info Req Authentication Info Answer	<b>→</b>		
	Security Mode Command Security Mode Complete	MME-3  MME-4	Location Update Req	,		
		MME-5	Location Update Answer Create Session Req	<b></b>		
						8

eNB App MME Function		Database	Timer	SPGW-HSS-Stub
Attach Req  MME-1  Authentication Request  Authentication Response  MME-3	Authentication Info Req Authentication Info Answer	-		
Security Mode Command  Security Mode Complete MME-4  MME-5	Location Update Req Location Update Answer Create Session Req	<b></b>		
	State Passing			
				8

eNB	S App M	ME Function		Database	Timer	SPGW-HSS-Stub
	Attach Req  Authentication Request  Authentication Response		Authentication Info Req Authentication Info Answer	<b>→</b>		
•	Security Mode Command Security Mode Complete	MME-3  MME-4	Location Update Req	,		
		MME-5	Location Update Answer Create Session Req	<b></b>		
						8

eNB App	M	ME Function		Database	Timer	SPGW-HSS-Stub
Att	ach Req	MME-1	Authentication Info Req Authentication Info Answer			
Autl	nentication Request	MME-2	Addition into Answer	<b>-</b>		
Auth	nentication Response	MME-3				
Secu	ırity Mode Command			<b></b>		
Secu	rity Mode Complete ,	MME-4	Location Update Req			
		MME-5	Location Update Answer Create Session Req			
	Attach Accept	MME-6	Create Session Response	<b>,</b>		
	'				Timer	
						8

eNB App M	ME Function		Database	Timer	SPGW-HSS-Stub
Attach Req	MME-1	Authentication Info Req Authentication Info Answer			
, Authentication Request	MME-2		-		
Authentication Response, Security Mode Command	MME-3		<b>→</b>		
Security Mode Complete	MME-4	Location Update Req			
	MME-5	Location Update Answer Create Session Req	<b></b>		
Attach Accept	MME-6	Create Session Response	<b>→</b>	Timer	
	/V\/V\C-/				
					8

eNB App MME Fu	nction	Database	Timer SF	PGW-HSS-Stub
Attach Req MMI	-1 Authentication Info Req			_
Authentication Request MMI	-2 Authentication Info Answer	<b></b>		
Authentication Response, MMI	2			
Security Mode Command	-3			
Security Mode Complete MMI				
MME	Location Update Answer  -5 Create Session Req	<b></b>		
Attach Accept MME	 Create Session Response	<b></b>	<b>,</b>	
Attach Accept MMI	-7		Timer	
				8

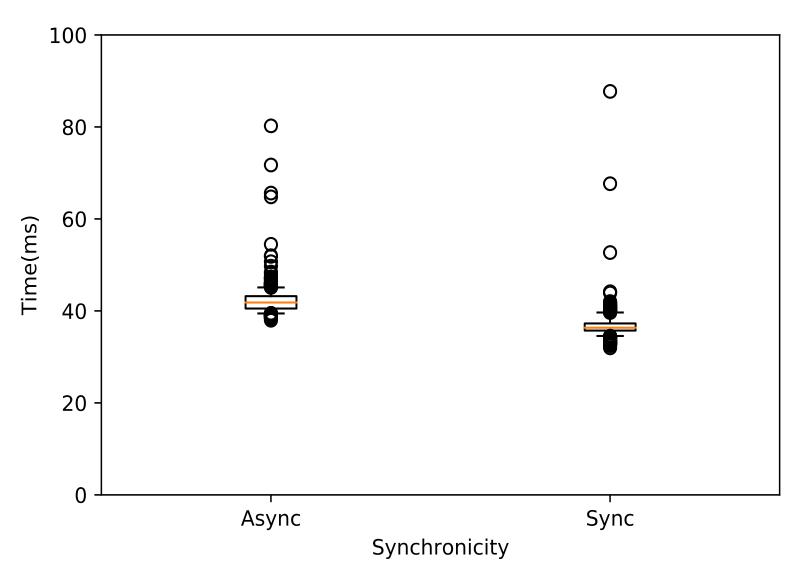
eNB App M	ME Function		Database	Timer	SPGW-HSS-Stub
Attach Req	MME-1	Authentication Info Req			
_ Authentication Request	MME-2	Authentication Info Answer			
Authentication Response					
Security Mode Command	MME-3		<b>→</b>		
Security Mode Complete	MME-4	Location Update Req			
	MME-5	Location Update Answer Create Session Req			
. Attach Accept	MME-6	Create Session Response	<b>→</b>		
Attach Accept	MME-7			Timer	
Attach Complete	MME-8	Modify Bearer Req (SGW)			
	MME-9	Modify Bearer Response			8

#### Design Principles

- Asynchronous responses
- Optimistic Concurrency Control
- State passing
- State Separation
- 3GPP timers

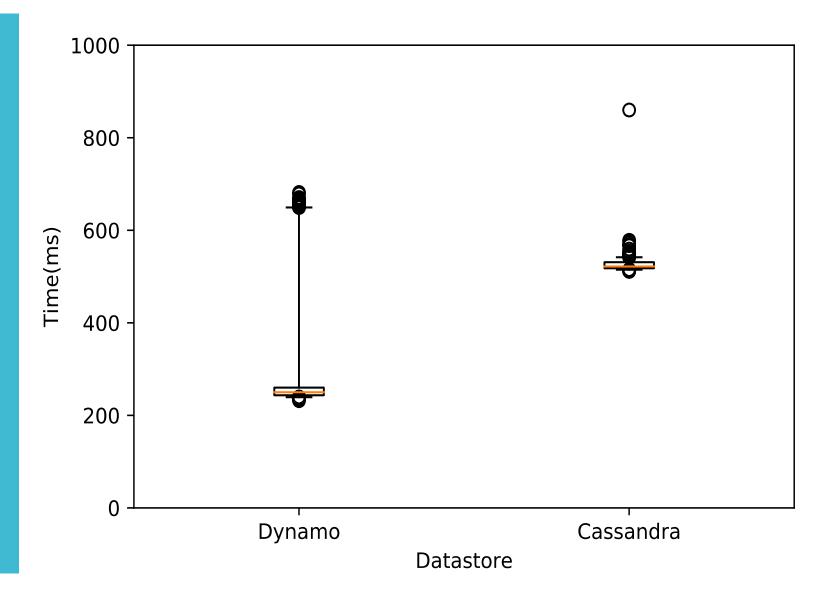
## Evaluation

# Evaluation – MME OpenFaaS



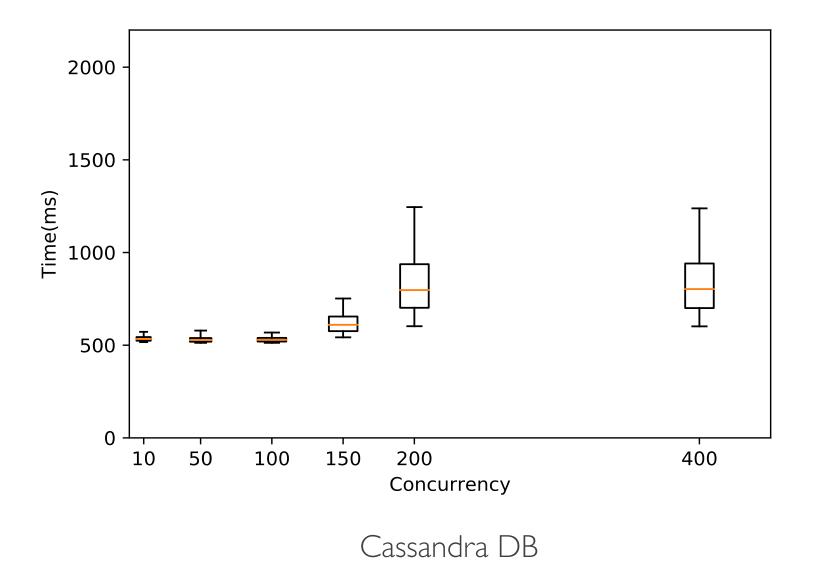
3GPP timer – UE side – Attach sent : Attach Accept – 15s

#### Evaluation – MME AWS Lambda



OpenEPC – 450ms OpenAirInterface – 1800ms

# Evaluation – Concurrency



## Evaluation – Why Cost?

- Functionality broken into measurable pieces
- Modelling of all interactions
- Cost can be predicted
- No way to compare with real deployments

Evaluation – Cost: 1 Attach

#### **Based upon AWS Pricing**

Cost element	Price per Attach	Percentage
Requests	0.0002 cents	4.5
Duration	0.0002 cents	4.5
API Gateway	0.0035 cents	75
DynamoDB Read	0.000100 cents	2.5
DynamoDB Write	0.000625 cents	13.5

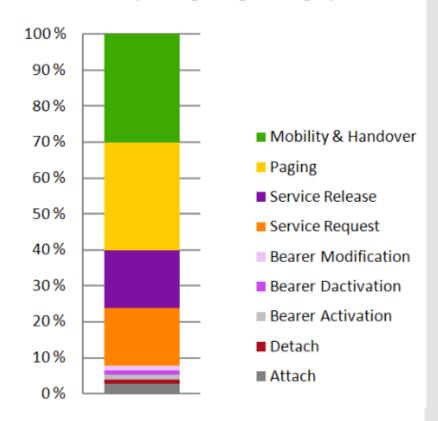
0.00465 cents per Attach, \$46.50 for 1M Attaches

#### Evaluation – Cost : Example distribution

### • We estimated cost for each of the procedure (details not discussed here)

- 1M events costs \$12.5
- 111.6M transactions per busy hour for
   1M subscribers
- Busy hour traffic for 1M subscribers costs \$1400

#### Subscriber Traffic Profile Example (% of signaling messages)



Example Source: Nokia Seimens. Signaling is growing 50% faster than data traffic. https://docplayer.net/6278117-Signaling-is-growing-50-faster-than-data-traffic.html.

### Future Work

#### Future work

- Compliance 4G or 5G
- Cost − API Gateway
- Cold start delay
- High availability



#### Serverless for MME Low latency

Cost