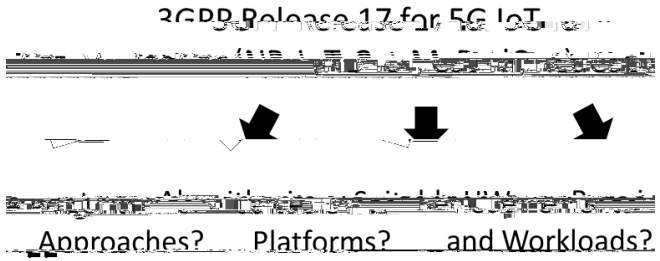
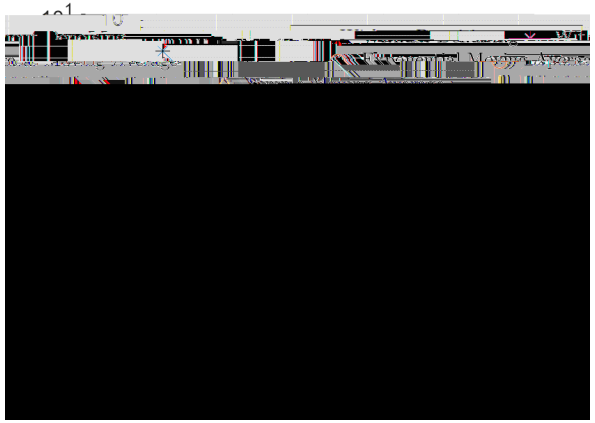




“Flexible Channel Estimation for 3GPP 5G IoT on a Vector Digital Signal Processor”

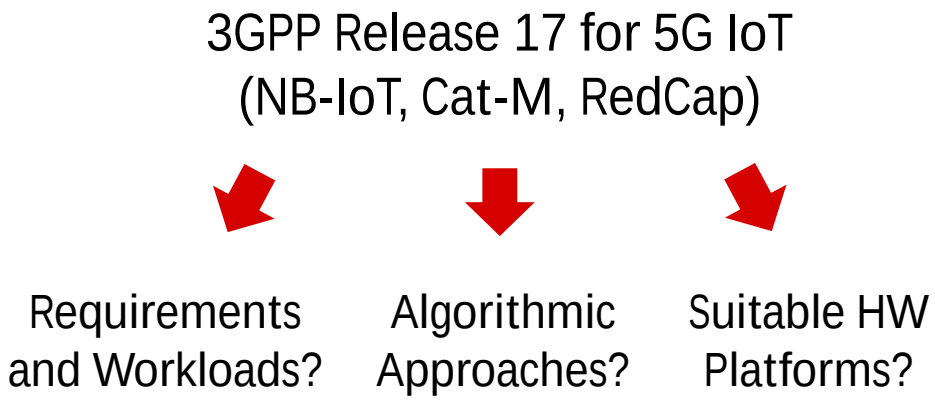
-
-
-
-
-

Stefan A. Damjancevic, , , , and Gerhard Fettweis,

VODAFONE CHAIR

Motivation: Introduction of RedCap for 3GPP 5G IoT

- NR Reduced Capability (RedCap/REDCAP/NR-Lite/NR-Light) to cover applications in the m[redacted] 7 n T 1 0 .



Workload, Platforms, Algorithms

Algorithmic Optimisation and 32-bit RISC Implementation

Further Algorithmic Optimisations:

- *β instead of (1-α)*

$$\tilde{H}(k,l) = \frac{1}{N_1+N_2+1}\sum_{i=l-N_1}^{l+N_2}\hat{H}(k,i).$$

$$\tilde{H}(k,l) = \alpha\hat{H}(k,l) + (1-\alpha)\tilde{H}(k,l-1),$$

$$\tilde{H}(k,l) = \alpha\sum_{i=-N_1}^{N_2}\hat{H}(k,l+i) = \sum_{i=-N_1}^{N_2}\alpha\cdot\hat{H}(k,l+i),$$

$$\tilde{H}(k,l) = \alpha\hat{H}(k,l) + \beta\tilde{H}(k,l-1),$$

Pseudo Code of Optimised Equations:

Algorithm 1: Moving Average in the SMA Form

input : Channel measurement $\hat{H}$ and filter coefficient g

output : Filtered channel measurement tildeH

```
// Data register v1
// ACC register w1
for l ← 0 to L − 1 do
  for k ← 0 to K − 1 do
  ...
  end
  ...
end
end
```

Algorithm 2: Moving Average in the EMA Form

input : Channel measurement $\hat{H}$ and filter coefficients α, β

output : Filtered channel measurement $\tilde{H}$

```
// Data register v1
// ACC register w1
v1 = 0;
for k ← 0 to K ...
```

Operations [1/ms]:

TABLE IV
NUMBER OF OPERATIONS.

Workload	Pilots [1/ms]	Operations [1/ms] SMA	Operations [1/ms] EMA	Filtering Axis
[illegible]	p	$p\cdot(N_1+N_2+1)$	$2p$	one axis
[illegible]	4	24	8	only t
[illegible]	12	72	24	only t
RedCap	424	5088 (70.7 × 72)	1696	both t,f
RedCap	2112	25344 (352 × 72)	8448	both t,f

32-bit reference Implementation:

TABLE V
32-BIT SCALAR REFERENCE: REQUIRED CLOCK FREQUENCY AND MISC UNIT UTILISATION

VODAFONE CHAIR

VODAFONE CHAIR

Results: Key Contributions

-
-
-

Algorithm	Moving Average based Channel Estimation					
Architecture	**32-bit scalar**		**vDSP128**		**vDSP512**	
Metric	Req. Clock [MHz]	Arithmetic Ops/Cycles [%]	Req. Clock [MHz]	SIMD Efficiency [%]	Req. Clock [MHz]	SIMD Efficiency [%]
NB-IoT	**0.25**	**89**	0.08	67	0.04	33
Cat-M	**1.28**	**97.8**	**0.34**	**92**	0.11	74
FR1 RedCap	25.9	99.89	**6.5**	**99.48**	**1.65**	**97.9**
FR2 RedCap	128.9	99.98	32.4	99.89	**8.09**	**99.58**

Standard	NB-IoT	Cat-M	FR1 RedCap	FR2 RedCap
Suitable Architecture	**32-bit**	**32-bit to 128-bit**	**128-bit to 512-bit**	**512-bit**