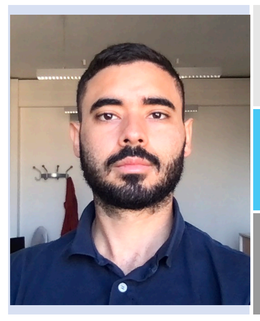
Adaptable programming models and compilers for 5G and beyond



Julian Robledo-Mejia
julian.robledo@tu-dresden.de
RoSI Associated Member
Prof. Castrillón-Mazo

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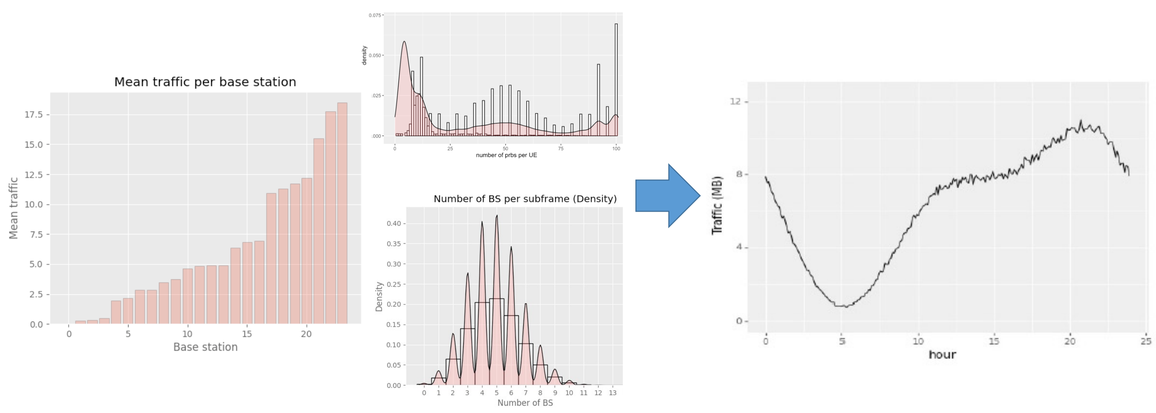
Challenges and motivation

- Mobile communication: ever increasing data demands under increasingly challenging real-time constraints
- High workload heterogeneity due to the variety of new usage scenarios/use cases in 5G
- Tremendous growth of power consumption
- High flexibility required in baseband systems to support the fast evolution of the telecommunication standards
- Addressing trade-off flexibility vs efficiency: Heterogenous platforms and dynamic HW reconfigurability as promising solutions

Understanding workload heterogeneity

- Understand heterogeneity of mobile communications workloads
- Profile workload parameters of real base stations
- Build traffic model to enable evaluation on multiple traffic scenarios



Model-based optimizations

- Use dataflow models to represent baseband signal processing systems and expose parallelism

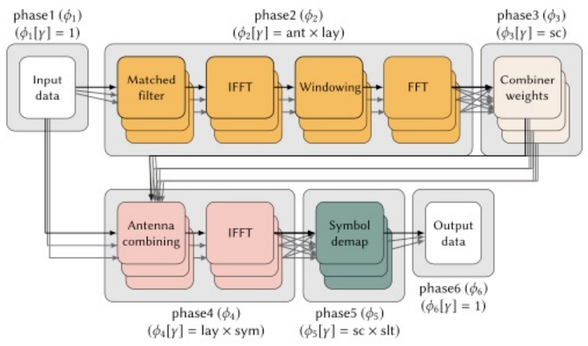
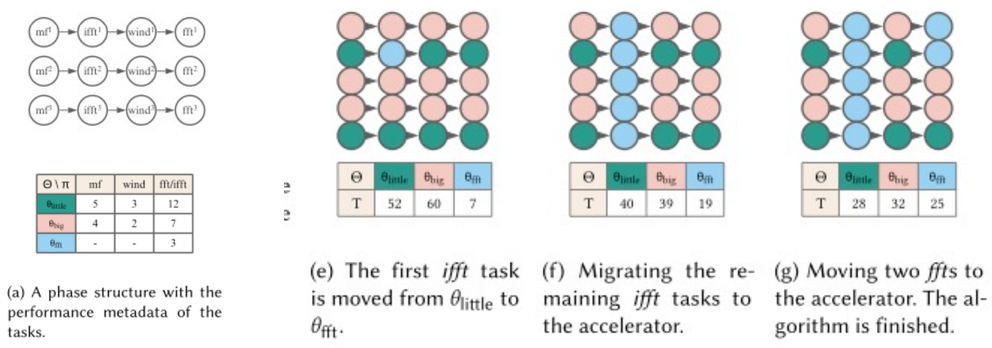


Fig. 1. Block diagram of a baseband receiver.

- Finding optimal scheduling of the applications onto heterogeneous platforms through hybrid compile-time/run-time approaches



Θ \ π	mf	wind	fft/ifft
θ_{little}	5	3	12
θ_{big}	4	2	7
θ_{fft}	-	-	3

(a) A phase structure with the performance metadata of the tasks.

Θ	θ_{little}	θ_{big}	θ_{fft}
T	52	60	7

(e) The first *ifft* task is moved from θ_{little} to θ_{fft}.

Θ	θ_{little}	θ_{big}	θ_{fft}
T	40	39	19

(f) Migrating the remaining *ifft* tasks to the accelerator.

Θ	θ_{little}	θ_{big}	θ_{fft}
T	28	32	25

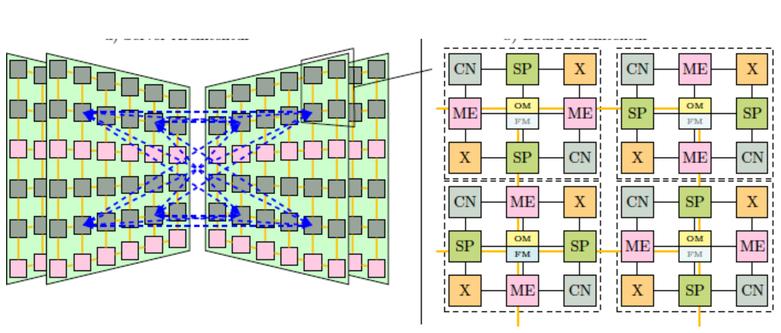
(g) Moving two *ffts* to the accelerator. The algorithm is finished.

Adaptive dataflow models: Reactors [1]

- Dataflow model for reactive systems that allows adaptive behavior and ensures determinism
- Ability to mutate internal topology at run-time

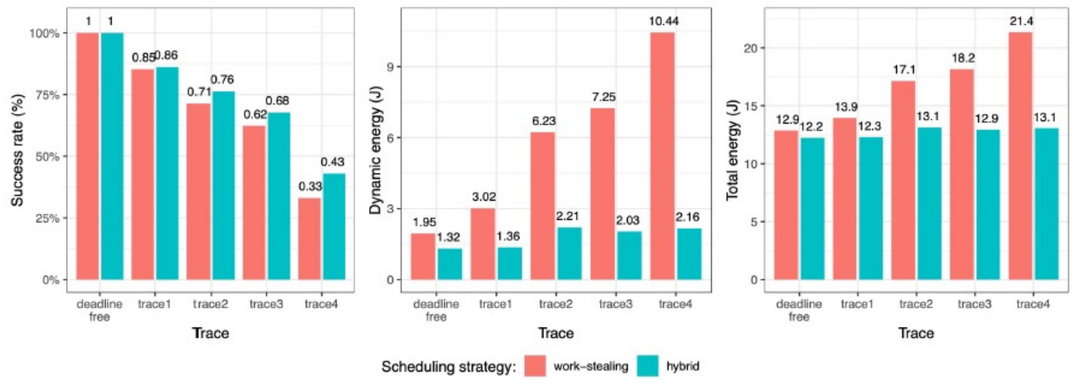
Hardware optimizations

- Adding dynamic hardware reconfiguration to enable resource-efficient and high-performance base stations
- E4C: Innovative concept for a scalable computer architecture that includes a novel bus structure with electrical, optical and wireless communication links



Preliminary results

- Simulation of a baseband system through a virtual prototype in Mocasin [2]
- Improved quality of service and power consumption by following an hybrid mapping strategy [3]



[1] Lohstroh, M., Romeo, Í.Í., Goens, A., Derler, P., Castrillón, J., Lee, E.A., & Sangiovanni-Vincentelli, A. (2019). Reactors: A Deterministic Model for Composable Reactive Systems. CyPhy/WESE

[2] Christian Menard et al. 2021. Mocasin - rapid prototyping of rapid prototyping tools: a framework for exploring new approaches in mapping software to heterogeneous multi-cores. In Proceedings of the 13th RAPIDO Workshop Conference. ACM, Budapest, Hungary, (Jan. 2021).

[3] Robert Khasanov, Julian Robledo, Christian Menard, Andres Goens, Jeronimo Castrillon, "Domain-specific hybrid mapping for energy-efficient baseband processing in wireless networks" (to appear), Proceedings of the 2021 International Conference on Compilers, Architecture, and Synthesis of Embedded Systems (CASES), IEEE Press, pp. 1-20, Oct 2021.