

Energy Efficient Analog Front Ends for Access Networks through Digital Signal Processing - A Contribution to Green ICT

Christian Vogel¹, Tomas Nordström², Steffen
Trautmann³, Gernot Kubin¹

vogel@tugraz.at

¹Institut für Signalverarbeitung und Sprachkommunikation, TU Graz

²FTW Forschungszentrum Telekommunikation Wien GmbH

³Lantiq Austria AG, Siemensstr. 4, A-9500 Villach

The Challenge



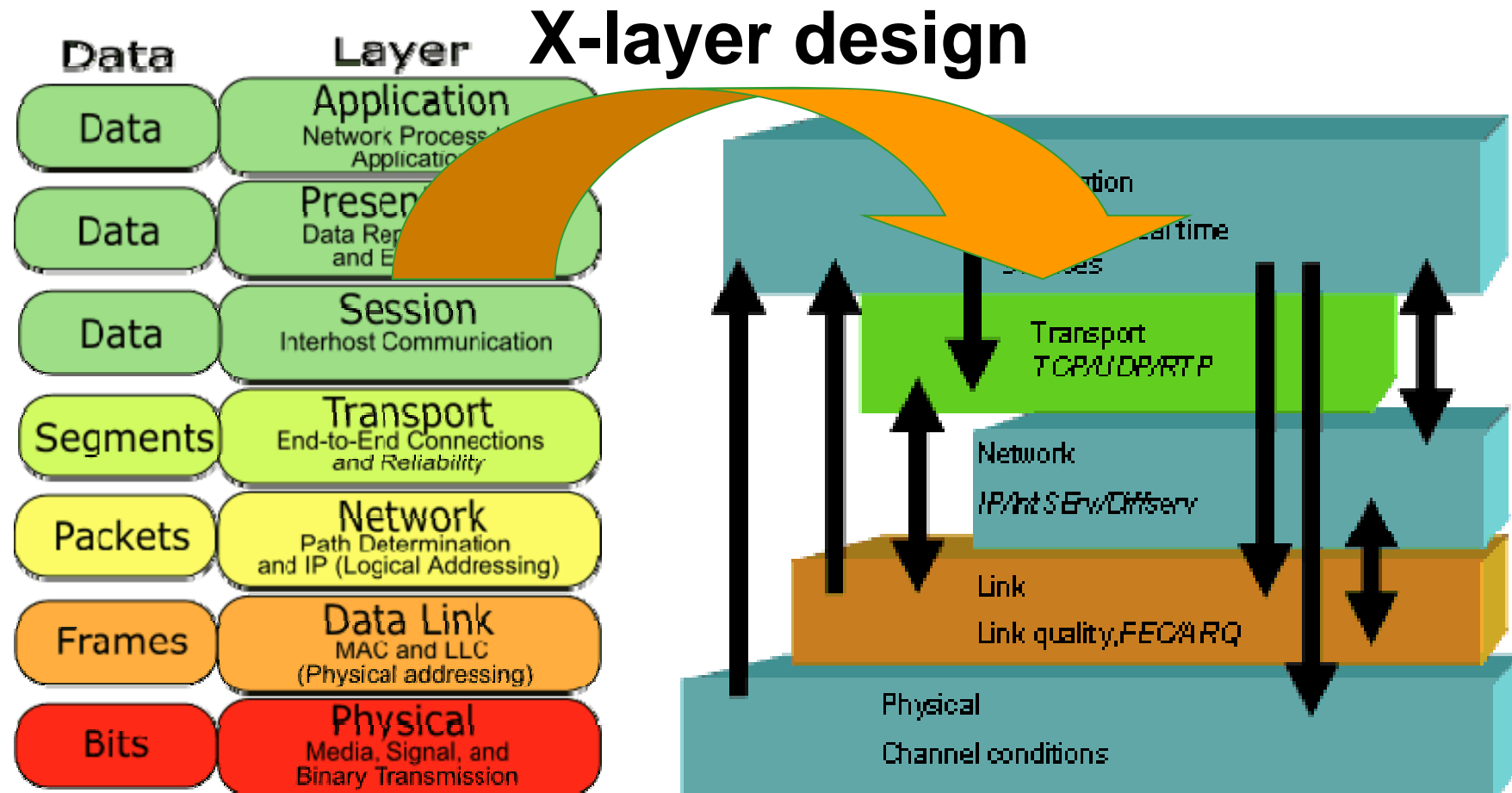
Telecom and Energy

- **Wired Networks Example**
 - The energy needed by the Telecom Italia's Network is more than 2000 GWh per year
 - Telecom Italia consumes nearly 1% of the total National energy demand
- **Wireless Network Example**
 - Vodafone's Network has an energy consumption of about 3000 GWh per year
 - It operates about 100000 radio base stations (RBS) worldwide
- **Rising tendencies**

The Tools



Cross-Layer Design



Small "layer violations" lead to significant improvements

Cross-Layer Design

- **Hardware layer approaches**
 - Improve the energy efficiency of the involved hardware
- **Transmission layer approaches**
 - Improve the energy efficiency of the involved transmission schemes
- **User and application layer approaches**
 - Improve user expectations and the applications behavior to support energy efficiency measures for the lower layers

Drawbacks of Cross-layer Design

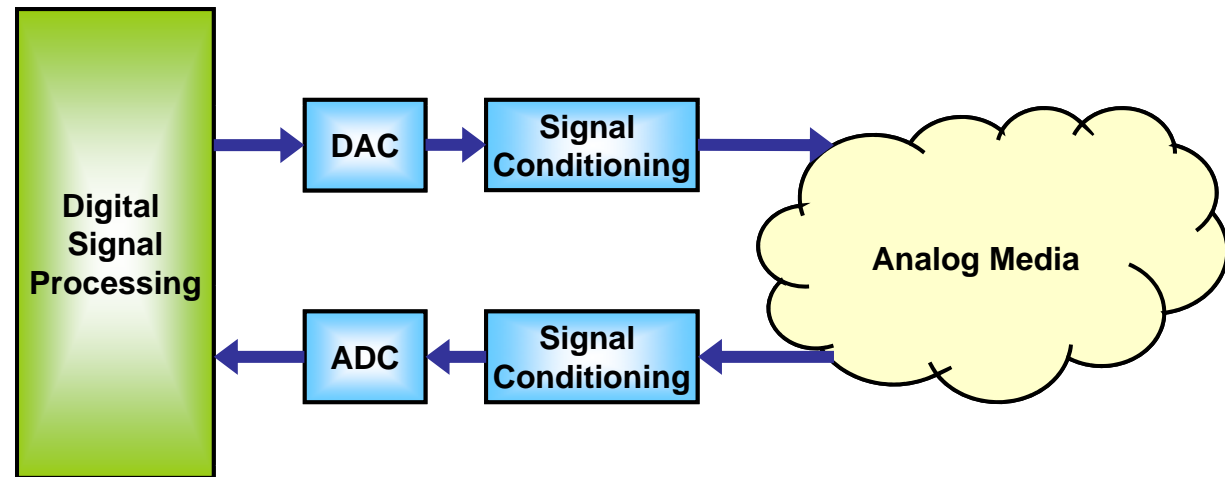
- The cooperating and cross-layer optimized blocks become closely coupled and application dependent
- Their reusability decreases
- The design complexity increases and engineers need a multi-disciplinary knowledge

Digital vs. Analog/RF Processing

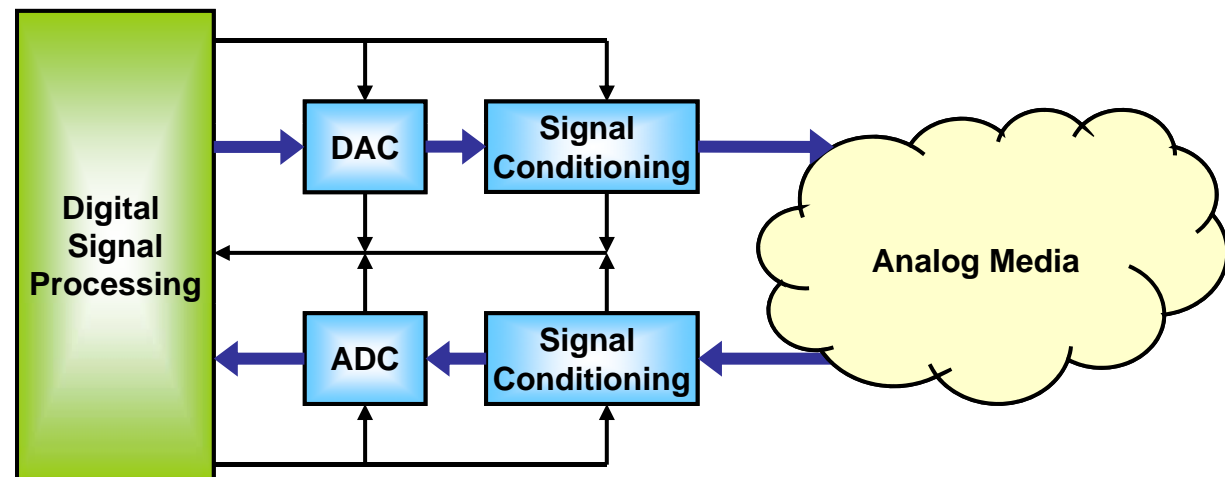
- There is a growing gap between the integration density of digital and analog/RF components
- One can exploit this gap for energy efficiency by applying two basic principles:
 - Move functionality from the analog/RF domain to the digital domain
 - Enhance/assist the analog functionality by digital signal processing

Digitally Enhanced Analog/RF Systems

Conventional system



Digitally enhanced system

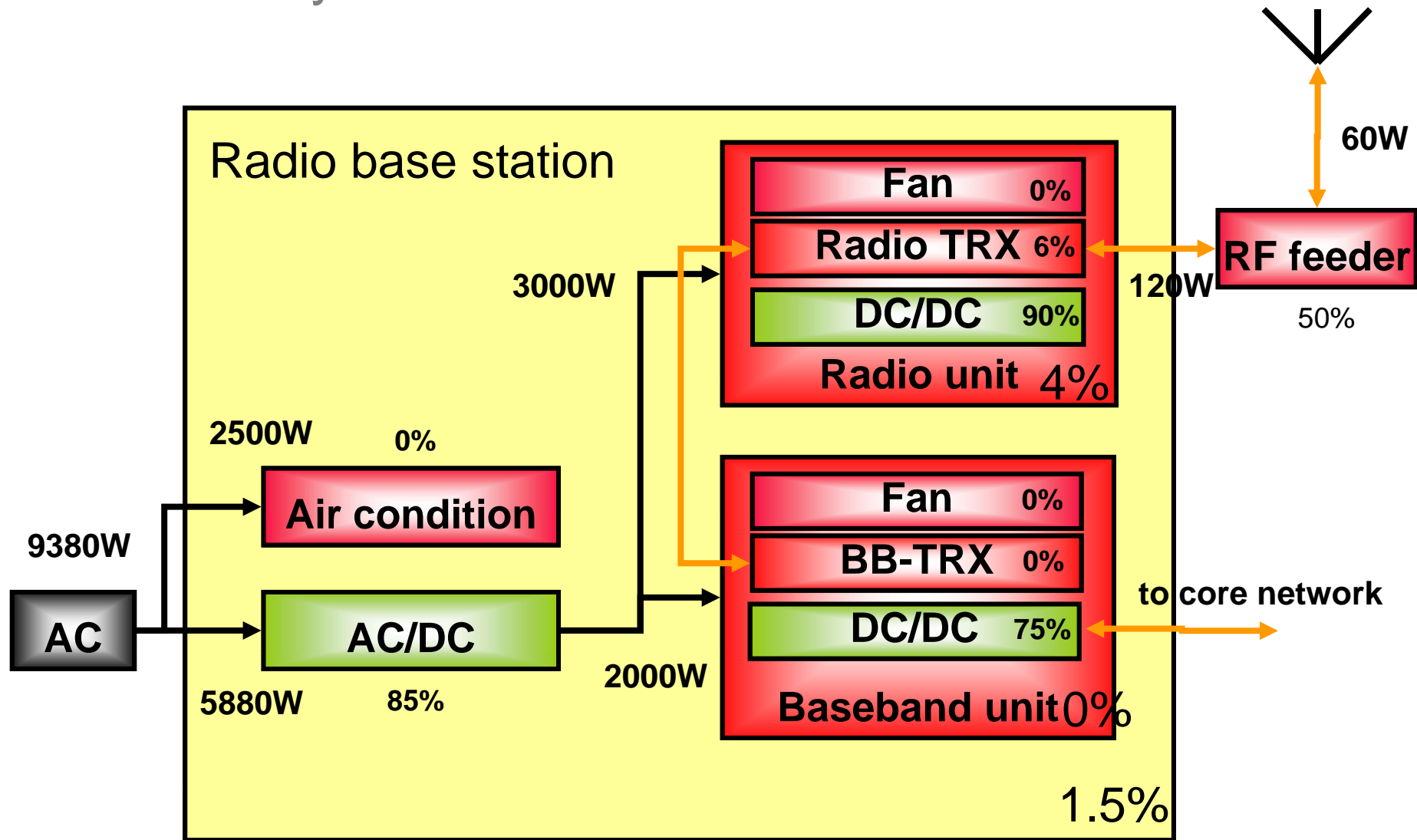


The Example

Radio Base Stations

- Studies of 3G wireless networks show that the RBS sites consume more than 80% of the power consumption for representative model networks
- Power consumption of additional digital signal processing is mostly negligible

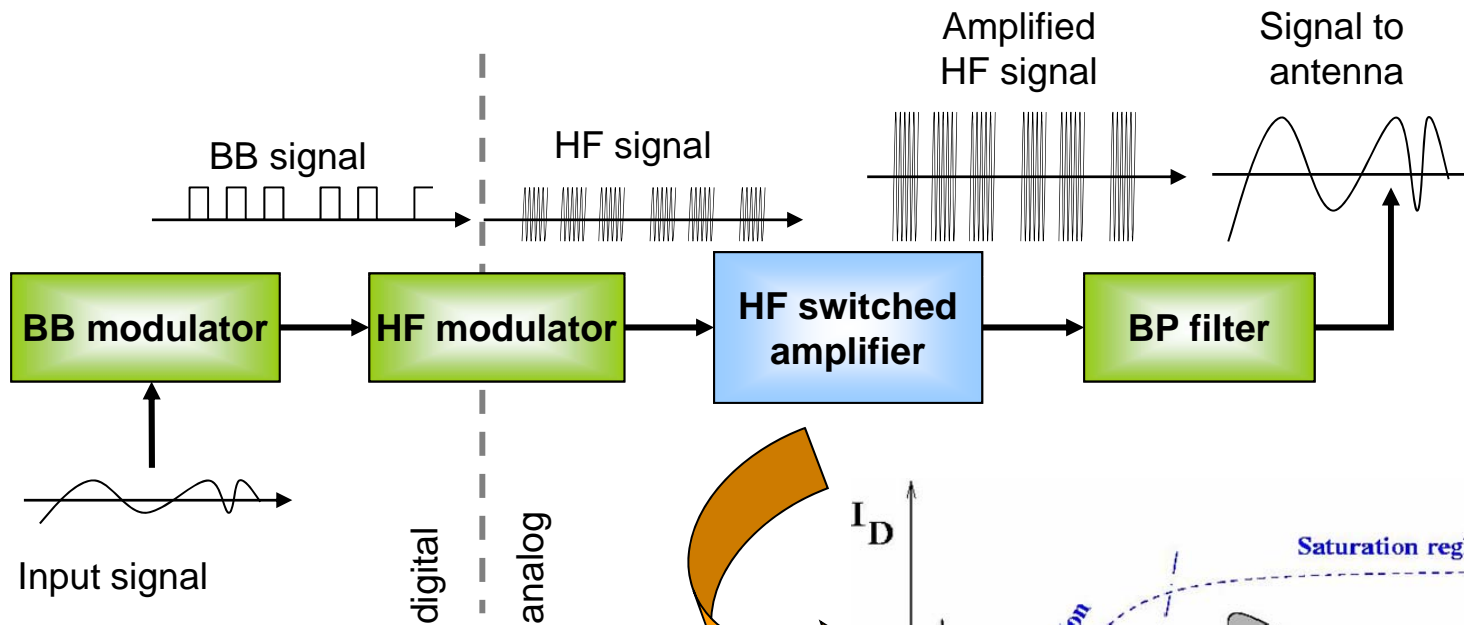
Efficiency and Power Loss in Radio Base Stations



Methods to Improve the Efficiency

- Move radio unit closer to the antenna
 - + Highest energy saving
 - Heavy unit placed in tower
 - Requires extended temperature range
 - Difficult maintenance
- Traffic adaptation/spectrum management
 - + Good energy saving
 - Knowledge of traffic situation required
 - Needs standardization
 - Fast wake-up time
- Highly efficient power amplifiers
 - + Good energy saving
 - Technically challenging

Burst Switched-Mode Power Amplifier

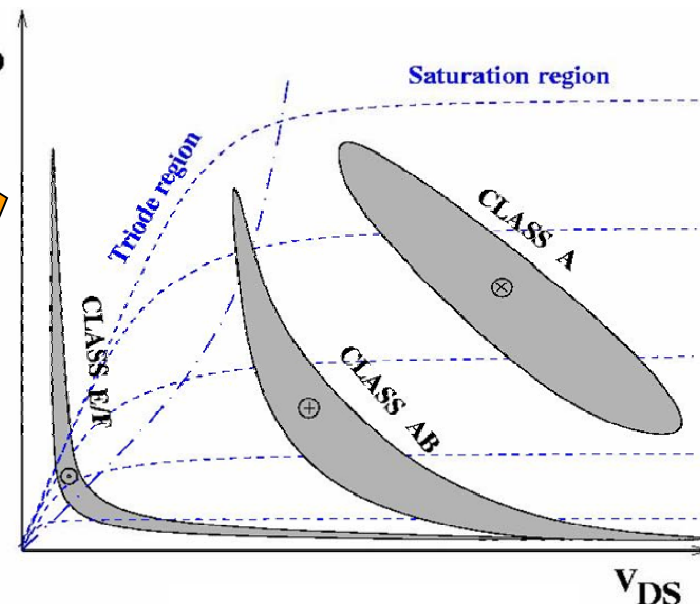
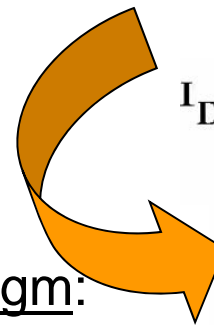


Challenges:

- Power amplifier design
- Predistortion
- Modulation
- Matching and filter design

Paradigm:

Avoid current and voltage at the same time



Impact of Efficient Power Amplifiers

- A change of the power amplifier efficiency from 15% to 45% would have a potential of 21 GWh less energy consumption per year only in Styria.
- This equals the power consumption of about 4900 three-person households in a whole year.

The Conclusions

Conclusions

- Access networks require more and more energy
- Digital signal processing can significantly improve the efficiency access networks
- Mobile devices pave the way to energy efficiency