Modular Link Layer Functions of a Generic Protocol Stack for Future Wireless Systems

L. Berlemann, A. Cassaigne, R. Pabst and B. Walke

Chair of Communication Networks (ComNets)
RWTH Aachen University, Germany

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Overview

- Introduction and Motivation
- Generic Protocol Stack in the Context of Multi-Mode Capable Wireless Networks
- Modular Approach
- Realization of Protocol Layers
- Conclusion and Outlook

Introduction and Motivation

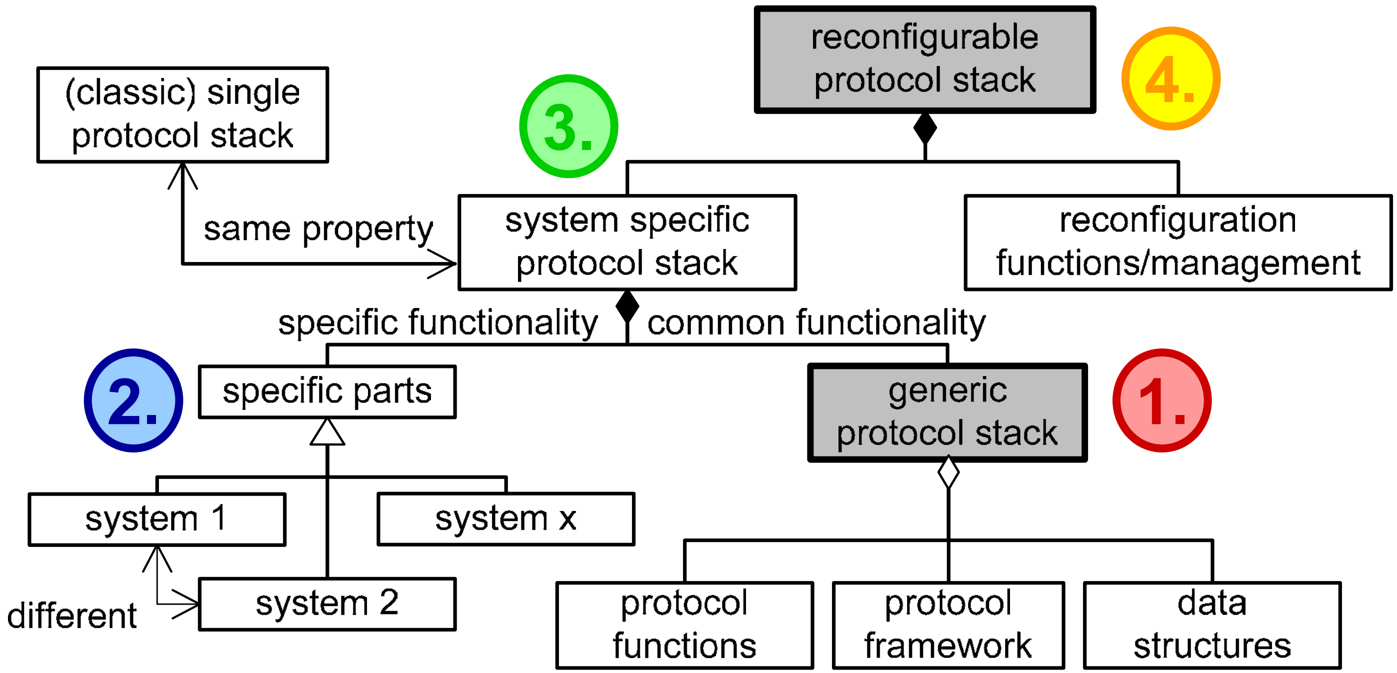
- Idea: Protocols share a lot of communalities, that can be exploited in an efficient reconfigurable wireless system

  → **Generic Protocol Stack**

- Advantages: runtime reconfigurability, maintainability, code/resource sharing and accelerated protocol development through reusability
- Generic part is crucial: Tradeoff - general usability vs. implementation effort
- Two approaches for realization, depending on the abstraction level of identified similarities:
  - Parameterizable modules including fundamental protocol functions
  - Inheritance of generic part(s) [1]

[1] M. Siebert, B. Walke, "Design of Generic and Adaptive Protocol Software (DGAPS)," in Proc. of 3Gwireless '01, San Francisco USA, June 2001

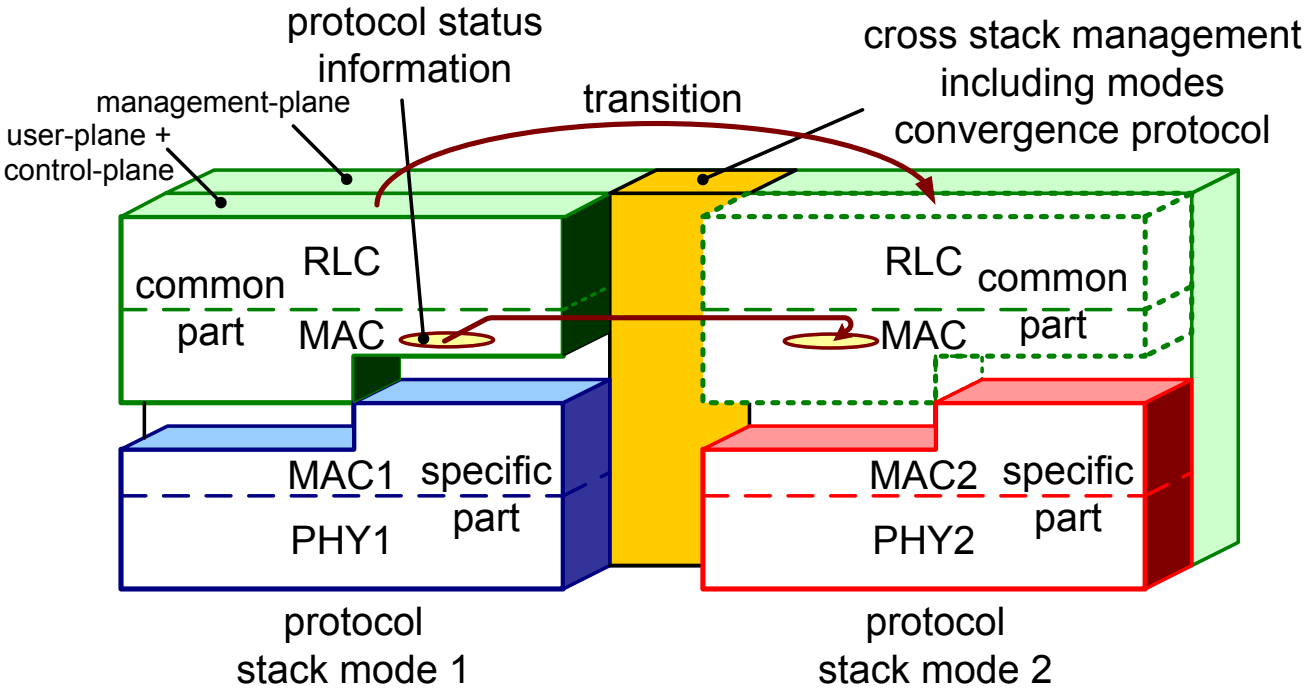
Generic Protocol Stack



- ... (step 4) ... (step 1) ... protocol layers ... (step 3) ... (step 2)
  - ... system
  - ... a flexible as well as efficient realization of a reconfigurable protocol stack
  - ... software design
  - ... of the individual behavior of a system

Enabling Transition between Multiple Modes

… with the help of a **Modes Convergence Protocol**.



- Separation into specific/generic part in each layer
- Management of (parallel existing) protocol stack/layer
- Administration of user data (seamless mode transition)
- Cross layer optimization (preservation of protocol status info)
- Support of network-initiated reconfiguration

Generic Protocol Functions of the Data Link Layer

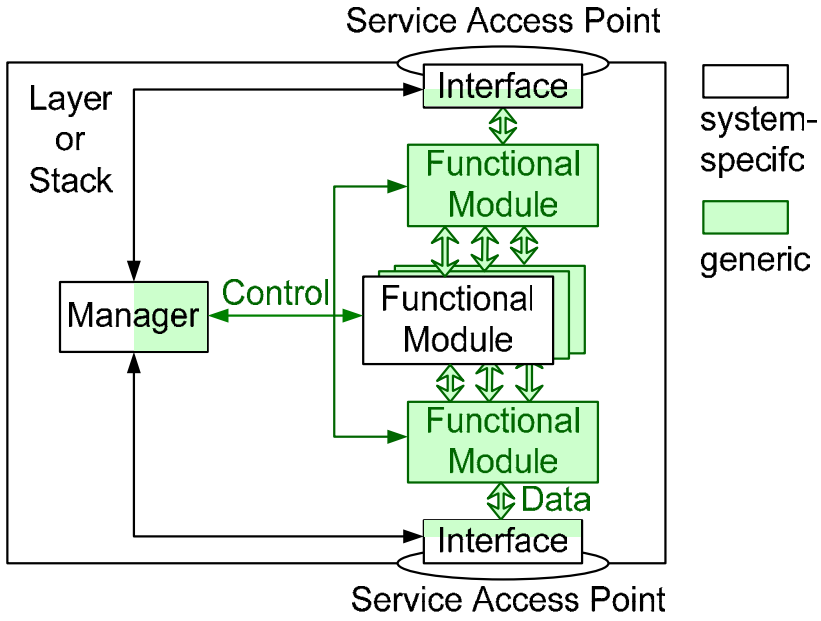
- Modern communication protocols cannot be forced into classical layered architecture of ISO/OSI RM
- Though belonging to Data Link Layer, common fundamental protocol functions can be found in multiple layers (2-4):
  - Error handling - Forward Error Correction or Automatic Repeated reQuest protocols [2]
  - Flow control
  - Segmentation, concatenation and padding of PDUs*
  - Multiplexing and De-Multiplexing
  - Dynamic Scheduling
  - Ciphering
  - Header Compression

[2] L. Berlemann, A. Cassaigne and B. Walke, "Generic Protocol Functions for Design and Simulative Performance Evaluation of the Link-Layer for Reconfigurable Wireless Systems," in Proc. of *WPMC'04*, Abano Terme Italy, September 2004

Modular Approach

- Common protocol functions as parameterizable modules and system-specific modules form a complete protocol layer
- Communication inside: generic service primitives and generic PDUs

- *Functional Module*: Realizes fundamental functionality as black box
- *Manager*: Composition, rearrangement, parameterization and data query of modules; Administration of internal communication
- *Interface*: Translation of generic service primitives to specific ones
- *Service Access Point*: Is needed, if a classical layer is demanded for fitting into ordinary stack



→ Simulation and performance evaluation on several levels: (sub-)layer as well as complete protocol stack

Parameterization of Functional Modules

Parameterization implies:

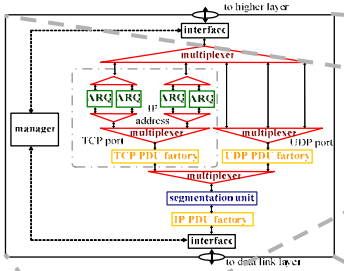
- Specification of a value
- Switching on/off of a behavior or functionality
- Extension of the modules' interface

Segmentation module as example:

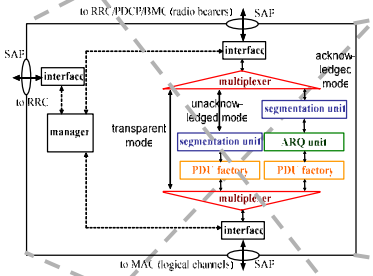
- Use of concatenation
- Targeted PDU size after handling
- Use of Padding, i.e. filling up of a PDU to reach a certain size
- Transmitter/Receiver Role
- Buffer size for SDUs concatenated in a single PDU
- Behavior in case of an error, i.e. interworking with ARQ module

Exemplary Protocol Layers

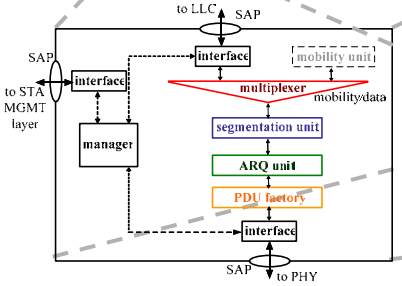
TCP/UDP/IP

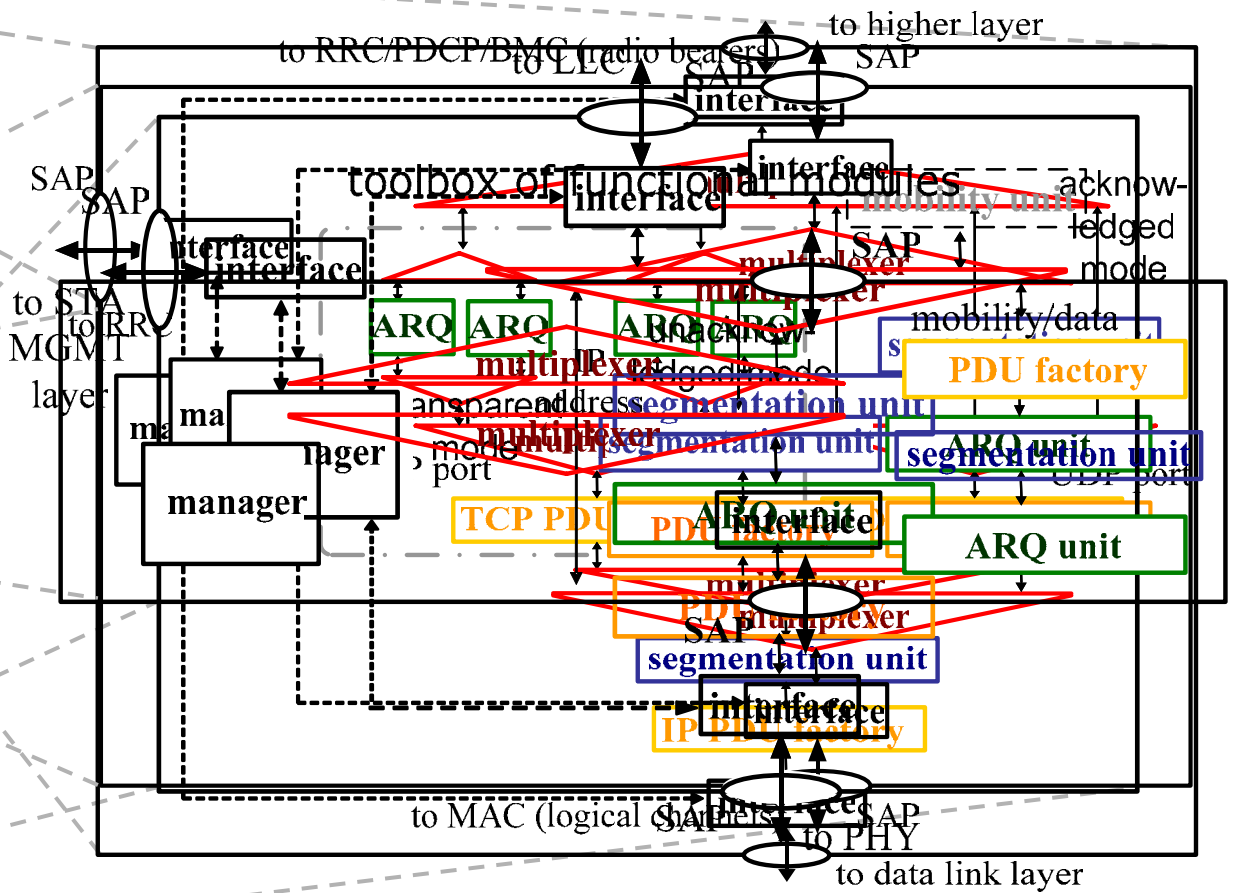


UMTS RLC



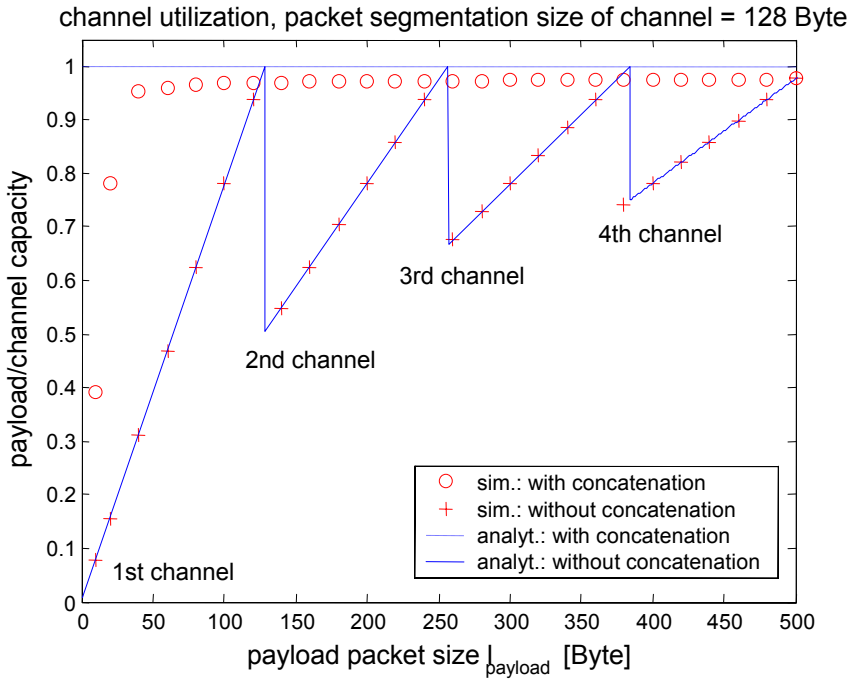
802.11 MAC





Segmentation Module as Example

SDU is separated into PDUs to fit to transport channel
Here: Segmentation aspects of UMTS RLC in Unacknowledged Mode



payload / channel capacity

protocol overhead without concatenation

protocol overhead with concatenation

$$\frac{payload}{channel\ capacity} = \frac{l_{payload}}{\left\lceil \frac{l_{payload}}{packet\ size} \right\rceil \cdot packet\ size}$$

packet size of payload is increased

- Protocol overhead vs. optimized channel utilization
- The segmentation module reflects the known behavior → it can be legitimately used in an multi-mode capable protocol stack

Conclusion and Outlook

- The identified similarities are decisive for success
  → tradeoff of genericity
- Generic protocol stack takes up well-proven and known fundamental protocol functions
- Existing (as shown) and future protocols (4G) can be composed out of adequately parameterized modules
- Library of common functions results in a construction kit for accelerated protocol development
- Efficient protocol reconfigurability through parameterization is enabled on the basis of functional modules

The introduced approach is a first step to an efficient multi-mode capable wireless system

Thank you for your attention !

Lars Berlemann
ber@comnets.rwth-aachen.de

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