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## Beyond 6LoWPAN

### Web Services in Wireless Sensor Networks

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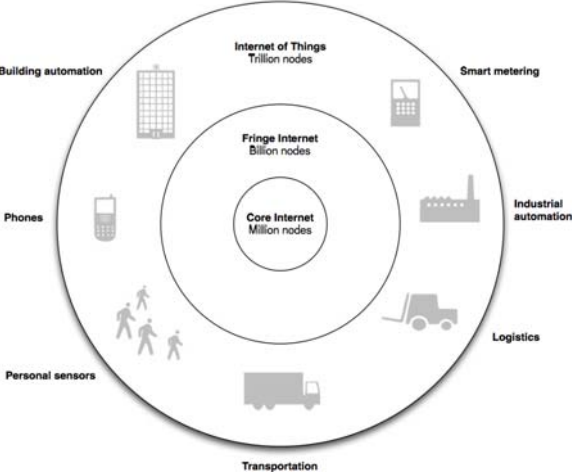
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## Motivation

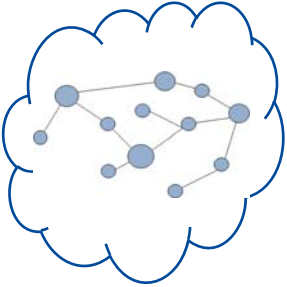
**Internet of Things Vision**

- ✓ Smart Environments adapting based on users behavior, users habits, environment conditions etc.
- ✓ Huge number of devices with (potentially) constrained resources (Wireless Sensor Networks)




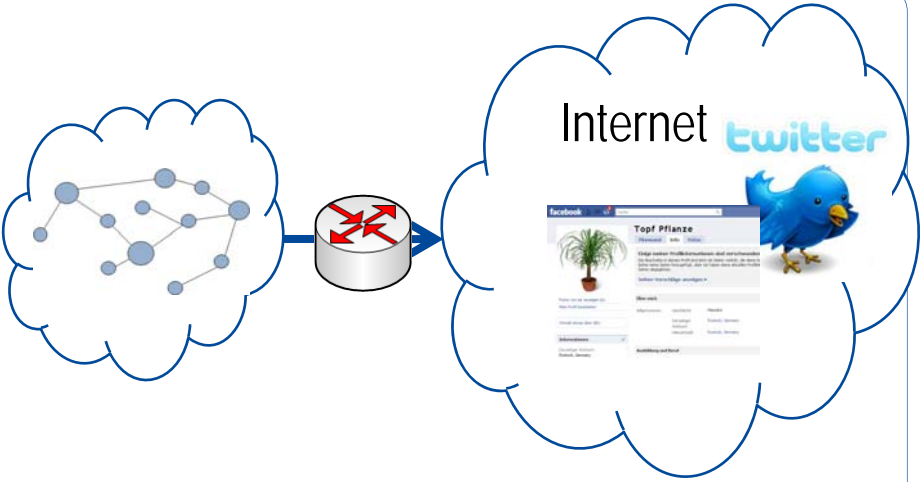
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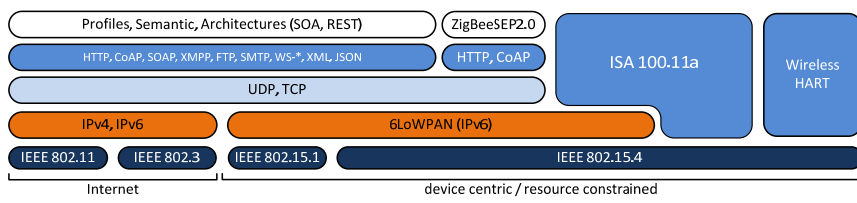
# Why Gateways are... Evil

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## Gateways and...

- inherent complexity
- flexibility and scalability (MUST use them)
- no end-to-end connectivity



Profiles, Semantic, Architectures (SOA, REST)    ZigBeeSEP2.0  
 HTTP, CoAP, SOAP, XMPP, FTP, SMTP, WS\*, XML, JSON    HTTP, CoAP  
 UDP, TCP    ISA 100.11a    Wireless HART  
 IPv4, IPv6    6LoWPAN (IPv6)  
 IEEE 802.11    IEEE 802.3    IEEE 802.15.1    IEEE 802.15.4  
 Internet    device centric / resource constrained

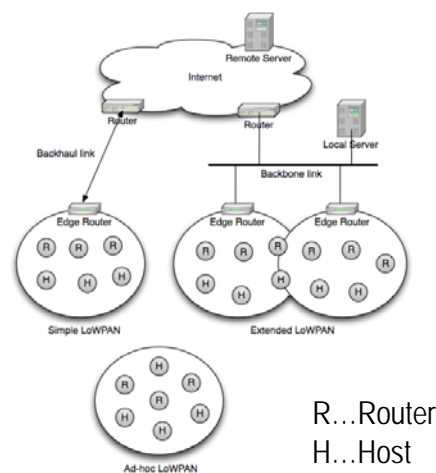
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## 6LoWPAN as key enabler

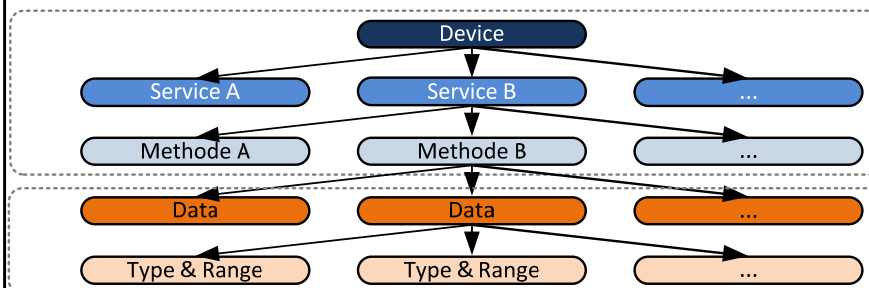
- IPv6 is not working natively over IEEE 802.15.4
  - Header Compression
    - Low Power Link, e.g. IEEE 802.15.4, has packet size of 127 bytes
    - Standard IPv6 header is 40 bytes, bad payload/header ratio
  - Fragmentation
    - IP packets may be large, compared to 802.15.4 max frame size
    - IPv6 requires all links support 1280 byte packets (c.f. 15.4 frame size of 127 bytes)
    - Interoperability means that applications need not know the constraints of physical links that might carry their packets
  - Neighbor Discovery (ND)
    - Networks may have multihop design
    - Nodes may be endpoints and routers at the same time

## 6LoWPAN – Architecture

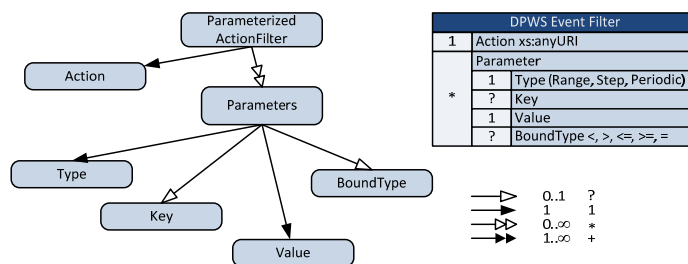
- 6LoWPAN optimizations/adaptations affect only the LoWPAN, not the rest of the internet
  - Compliant (stateless, transparent) conversion on edge routers
- Simple LoWPAN
  - One Edge Router
- Ad-hoc LoWPAN
  - Stand alone, no backbone
- Extended LoWPAN
  - Multiple LoWPAN confederated via backbone



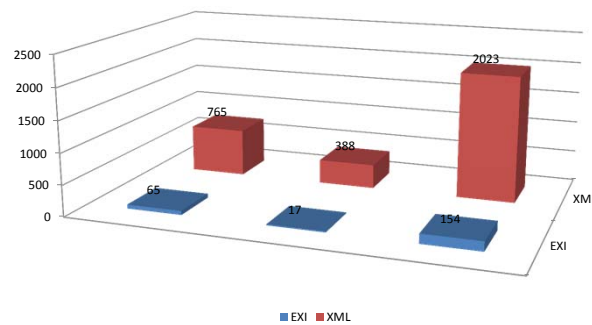
- Slightly changed discovery phase
- Fine grained event filters
- Efficient binary encoding
- Lightweight transport binding

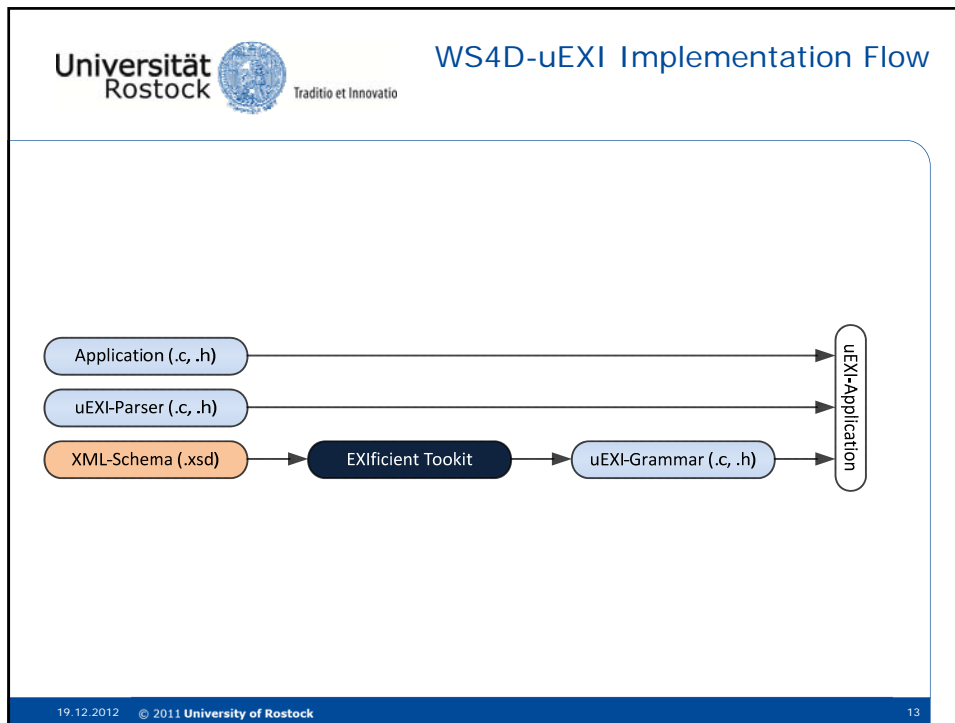



- Extend existing filtering mechanisms to data
- Allows e.g. threshold monitoring, periodic notifications,...
- Combine different filters with logical OR



- EXI (W3C Efficient XML Interchange) is powerful enough!
- From left to right: average, minimum and maximum of the 18 messages
- Preferred EXI mode: schema-informed, bit aligned, uncompressed, non-strict
- EXI maps seamless and stateless with XML!



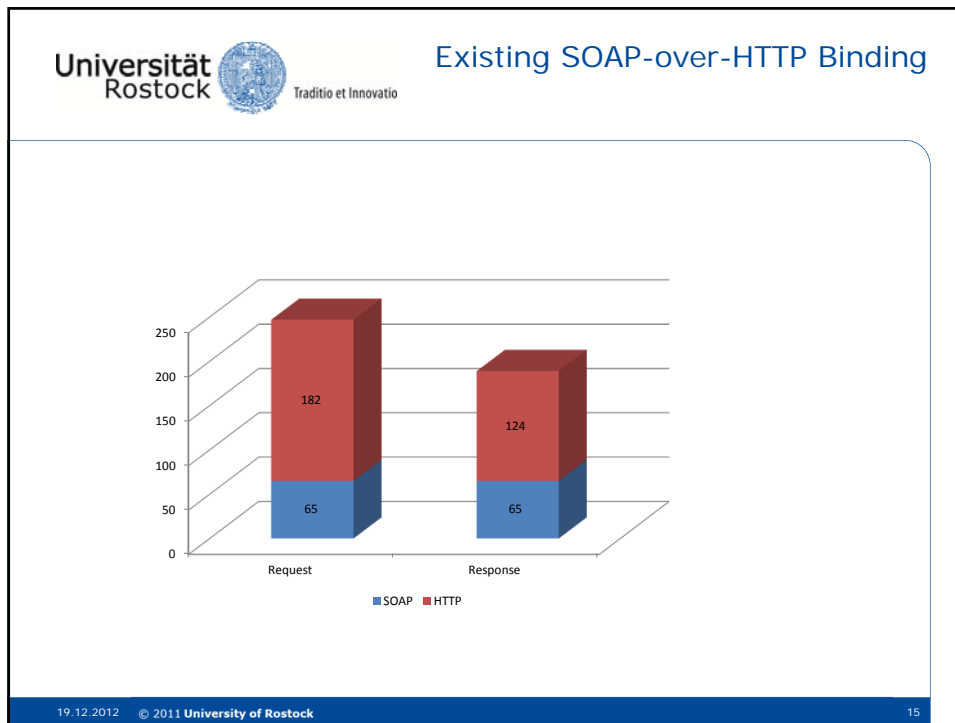




WS4D-uEXI ROM Usage

- Parser ROM usage is negligible
- Application specific grammar extensions are negligible, but reduce message size significantly

Module und Grammatiken	ROM [Byte]	Diff [Byte]
uEXI-Parser (entspricht schema-less)	1.088	-
+SOAP, XML, XML-Schema, XML-Namespace	4.372	3.284
+WS-Addressing	7.002	2.630
+WS-Eventing	10.588	3.586
+WS-MetadataExchange	11.672	1.084
+WS-Discovery	15.246	3.574
+DPWS	17.692	2.446
+Air Conditioner (Referenzszenario)	18.000	308

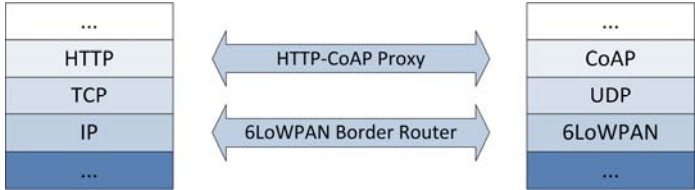
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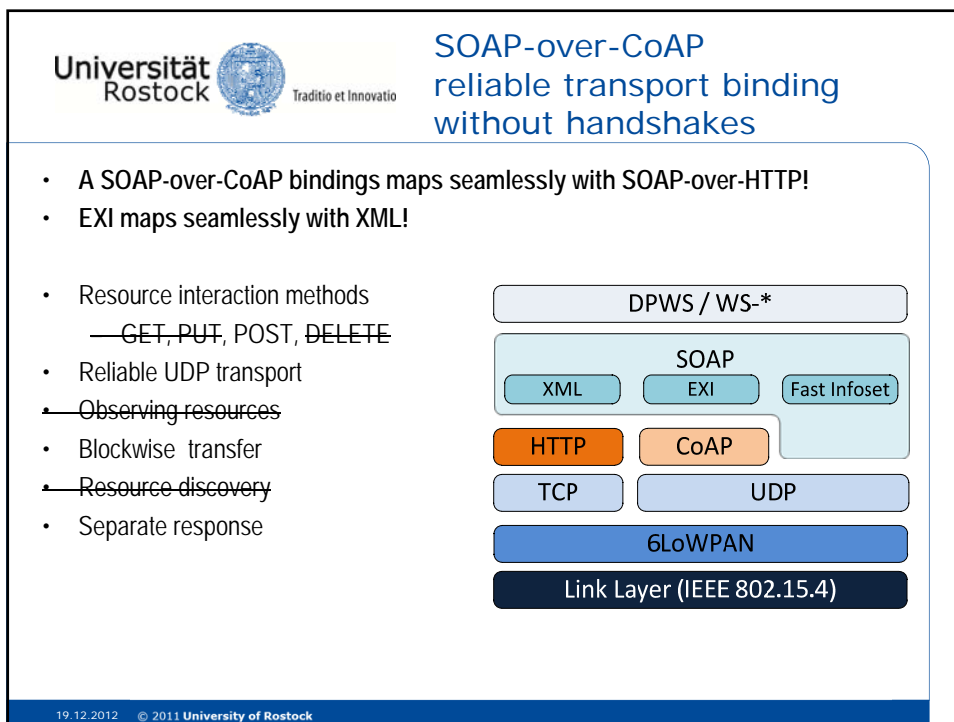
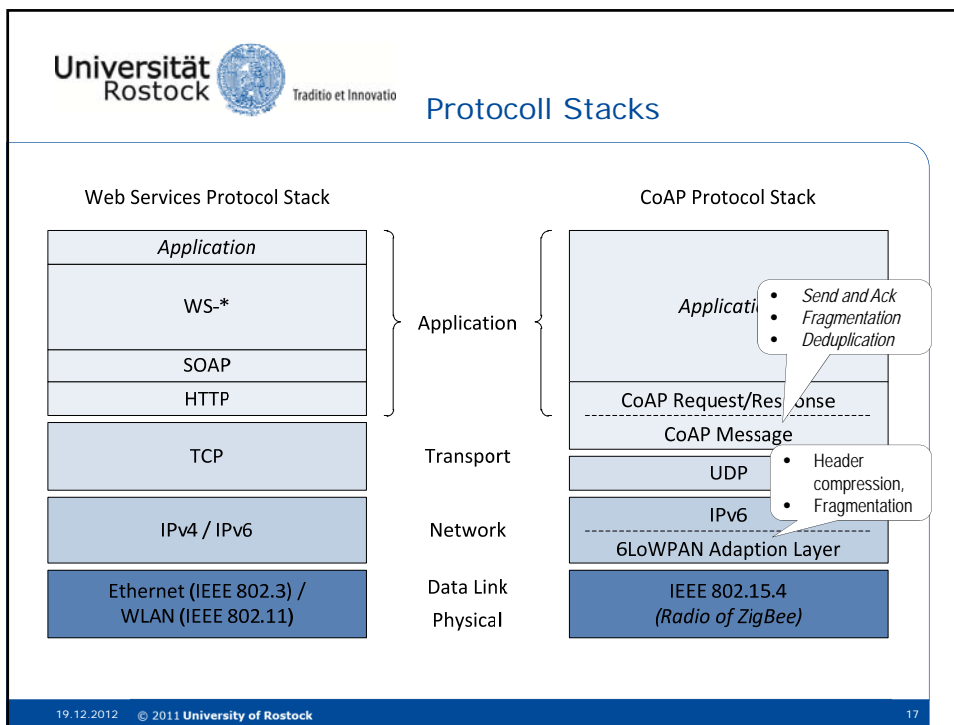
## CoAP in a Nutshell

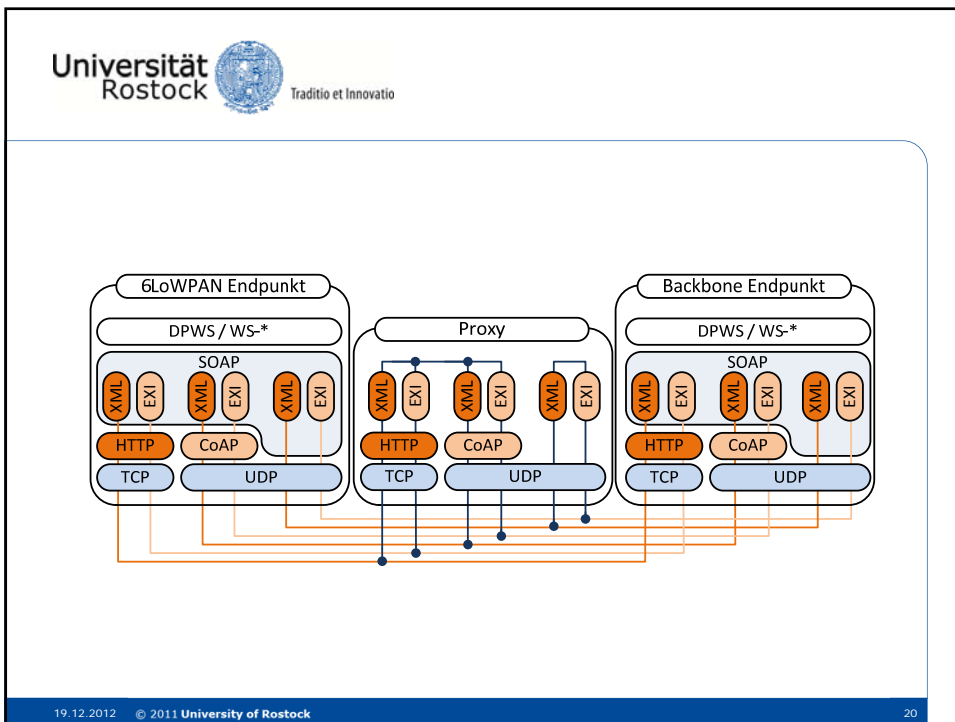
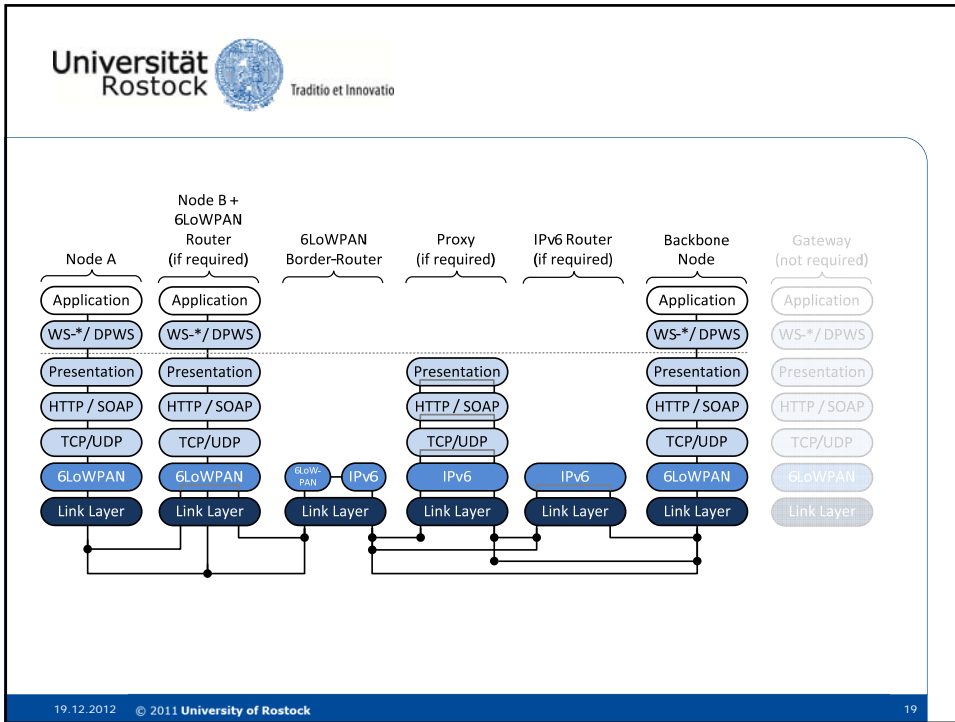
- ✓ CoAP is a **lightweight HTTP alternative** for constrained environments and nodes
  - ✓ CoAP is **NOT** binary HTTP (but thinking of it like that makes it easier to understand)
  - ✓ For **M2M** applications
- ✓ Specified by the **IETF Constrained RESTful environments (CoRE) Working Group**.
  - ✓ Status: 4 Internet-Drafts (1 main draft + 3 satellites)
- ✓ **CoAP maps seamlessly and transparently with HTTP**
  - ✓ Exactly like 6LoWPAN does with IPv6

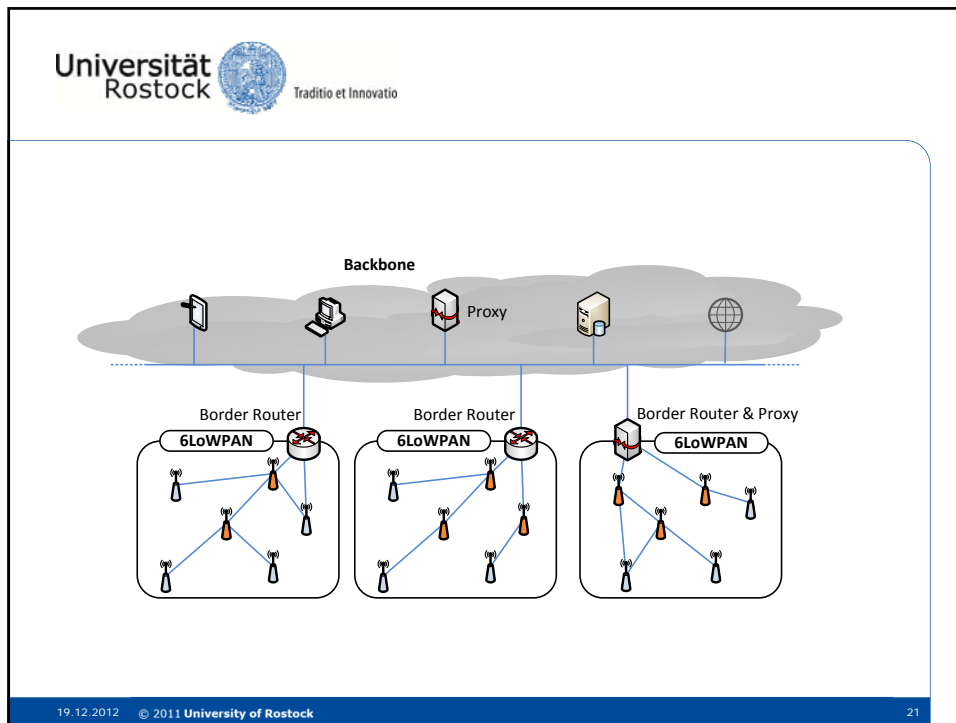


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