Funknetzwerke mit niedrigen Datenraten Aspekte von H/W Lösungen für heute und morgen

ATMEL – Microcontroller Wireless Solutions

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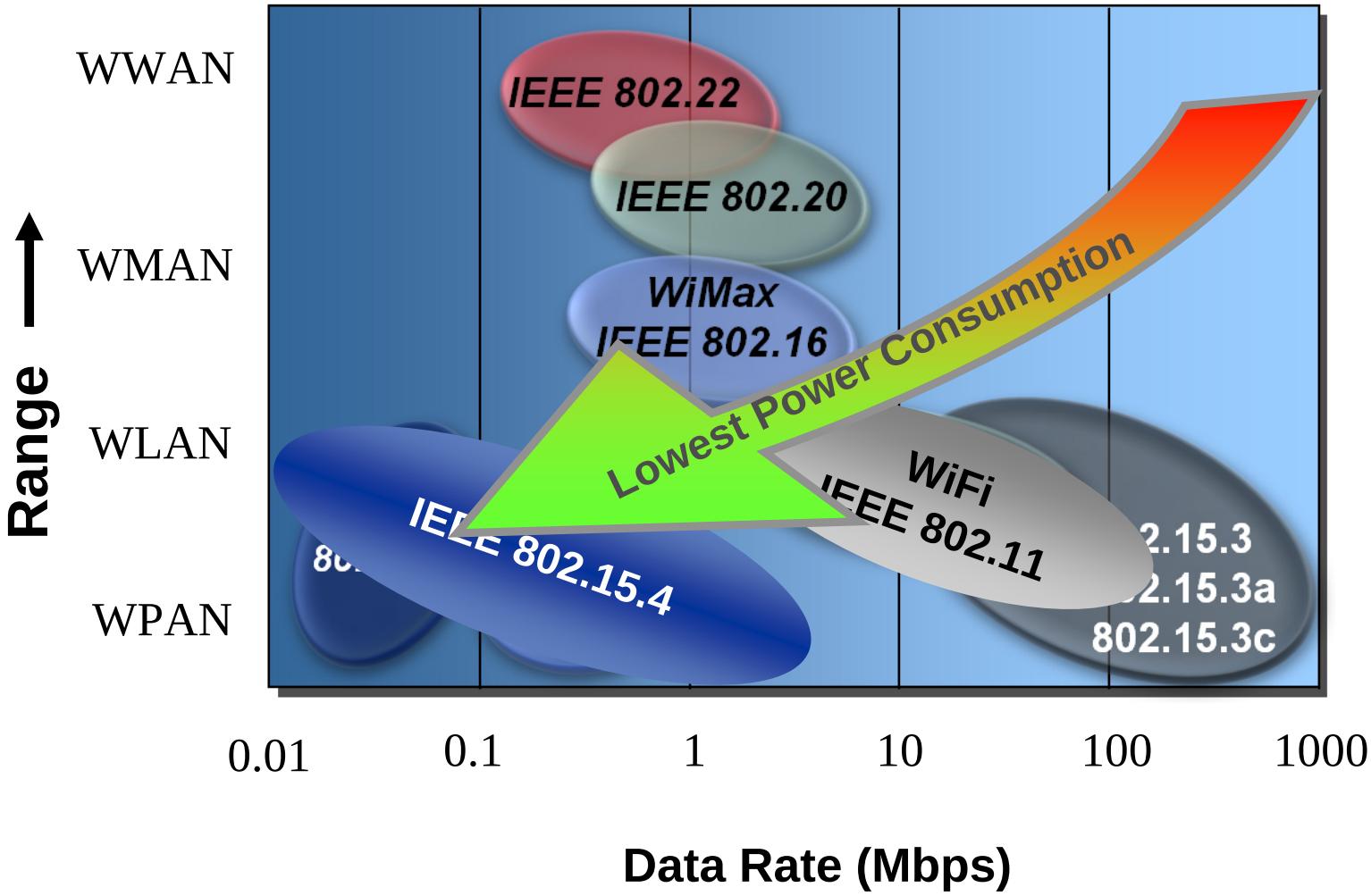
Presentation Overview

1. Introductory Overview
2. System Characteristics (Selection)
   - Coexistence
   - RF Performance
   - Power Consumption
3. System Characteristics – Appl. Example
4. Summary

The IEEE802 wireless space



Characteristics of Low Data Rate Wireless Network Nodes

- RF and system performance
  - TX power & Receiver sensitivity (Path loss)
  - Ranging
  - …
- Power consumption
- System cost
  - External components
- Flexibility of system solution
  - Diff. uC
  - One chip vs dual chip solution
  - Protocol stacks
  - Applications
- Increasing requirements on Coexistence
- Interoperability
- …

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Coexistence Subject using IEEE 802.15.4 as example (1)

1. **CCA (clear channel assessment) using CS (carrier sense) and ED (energy detect)**
   - Collision avoidance mechanism (carrier sense multiple access with collision avoidance, CSMA-CA), applied to 2.4G and sub-1 GHz
   - ED and LQI (link quality indicator) are measurements used for CSMA-CA to characterize interference situations
2. **Dynamic Channel Selection**
   - Not required for 868 MHz
   - Mandatory for 2.4 GHz – requires resources and time, increase power consumption
     - ChannelList parameters are to be adapted for varying interference scenarios
   - (Adaptive) Frequency Hopping is about getting standardized to an larger extent
3. **Modulations schemes**
   - 2.4 GHz O-QPSK (sine shaped, MSK equivalent) allows a power-efficient modulation scheme
   - Sub-1 GHz bands using bandwidth limited modulation schemes
   - 868 MHz is not affected by adjacent/alternate channel interferences
   - 915 MHz has typically a higher selectivity due to narrowband characteristic

Coexistence Subject using IEEE 802.15.4 as example (2)

5. Low duty cycle

- IEEE802.15.4 specification is tailored for application with low power and low data rate
- Typical applications are anticipated to run with low duty cycle as well
- A low duty cycle reduces the risk of interferences
- Battery operated devices suffer from increasing duty cycle

4. Channel alignment

- *Not* required for 868 MHz
- Mandatory for 2.4 GHz – requires resources and time, increase power consumption
- 2.4 GHz channel alignment reduces the number of available channels significantly
  - 4 out of 16 channels in guard bands between 802.11b
  - Interferences in guard bands are likely due 802.11 TX side lobes

6. Low transmit power

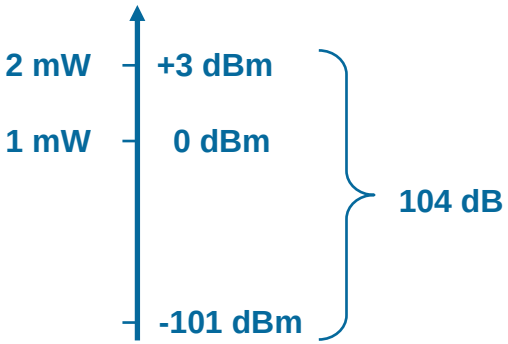
- Applicable to all 802.15.4 bands
- Sub-1 GHz systems are likely to operate at lower power because of
  - Better propagation conditions, and
  - Less interferences

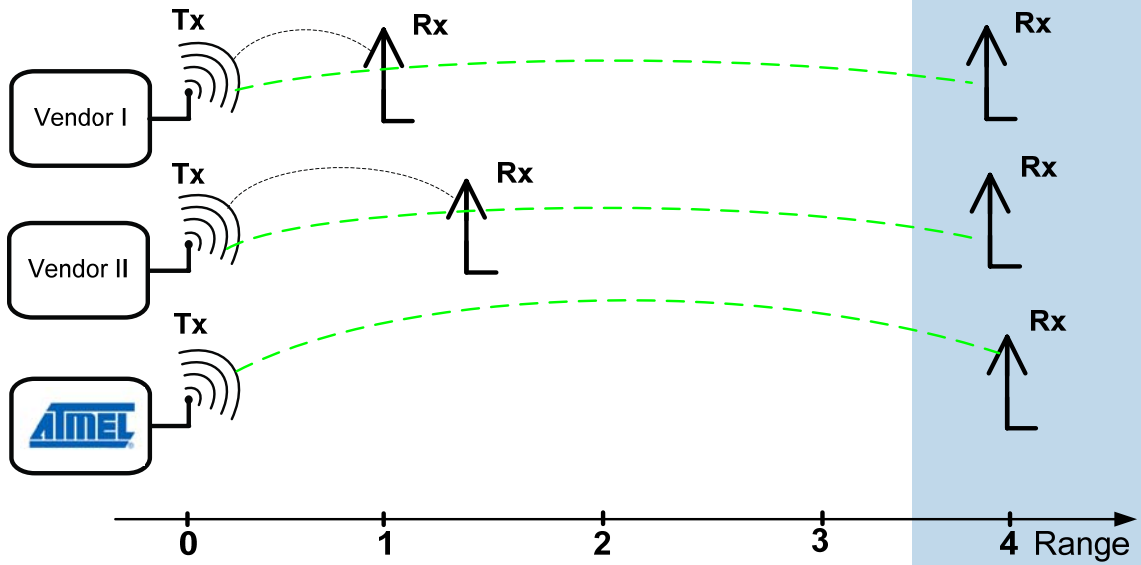
Evolution of RF Performance

	Tx	Rx	Link
TRX1*	0dBm	-92dBm	92dB
TRX2*	+2.5dBm	-100dBm	102.5dB
TRX3*	0dBm	-95dBm	95dB
TRX4*	+5dBm	-98dBm	103dB
Atmel RF230*	+3dBm	-101dBm	104dB

e.g. Atmel AT86RF230:

- **Linkbudget 104dB**
- **RX Sensitivity -101dBm**
- **TX Power +3dBm**





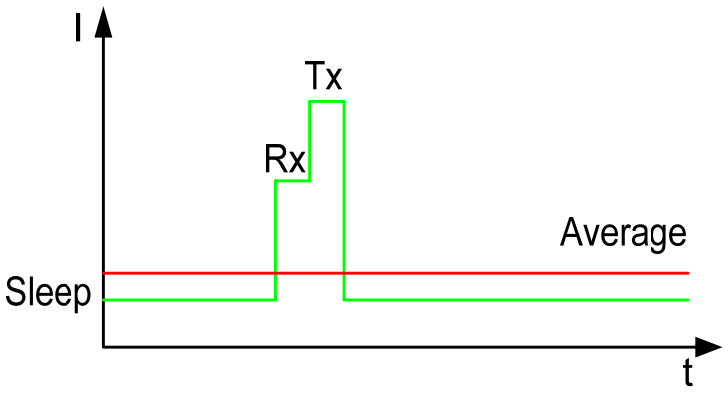
(*) TRX parameter from datasheets available on web

Evolution of Power Consumption

e.g. Atmel AT86RF231:

- **Sleep 20 nA**
- **Receive ~13 mA**
- **Transmit ~14 mA**

	Tx	Rx	Sleep
TRX3*	17mA	19mA	20µA
TRX4*	33mA	22mA	1µA
TRX1*	30mA	37mA	1 µA
Atmel RF230*	16mA	15 mA	0.02 µA
Atmel RF231*	14 mA	13 mA	0.02 µA



= years of battery lifetime

Example:

Temp Sensor Application

AT86RF230 + ATmega1284P

Battery: AA Li-Thionyl-Cl

Sleep : < 600 nA w/RTC

Active: ~ 20 mA

Temp every 30 Sec

Lifetime > 8 years

(*) TRX parameter from datasheets available on web

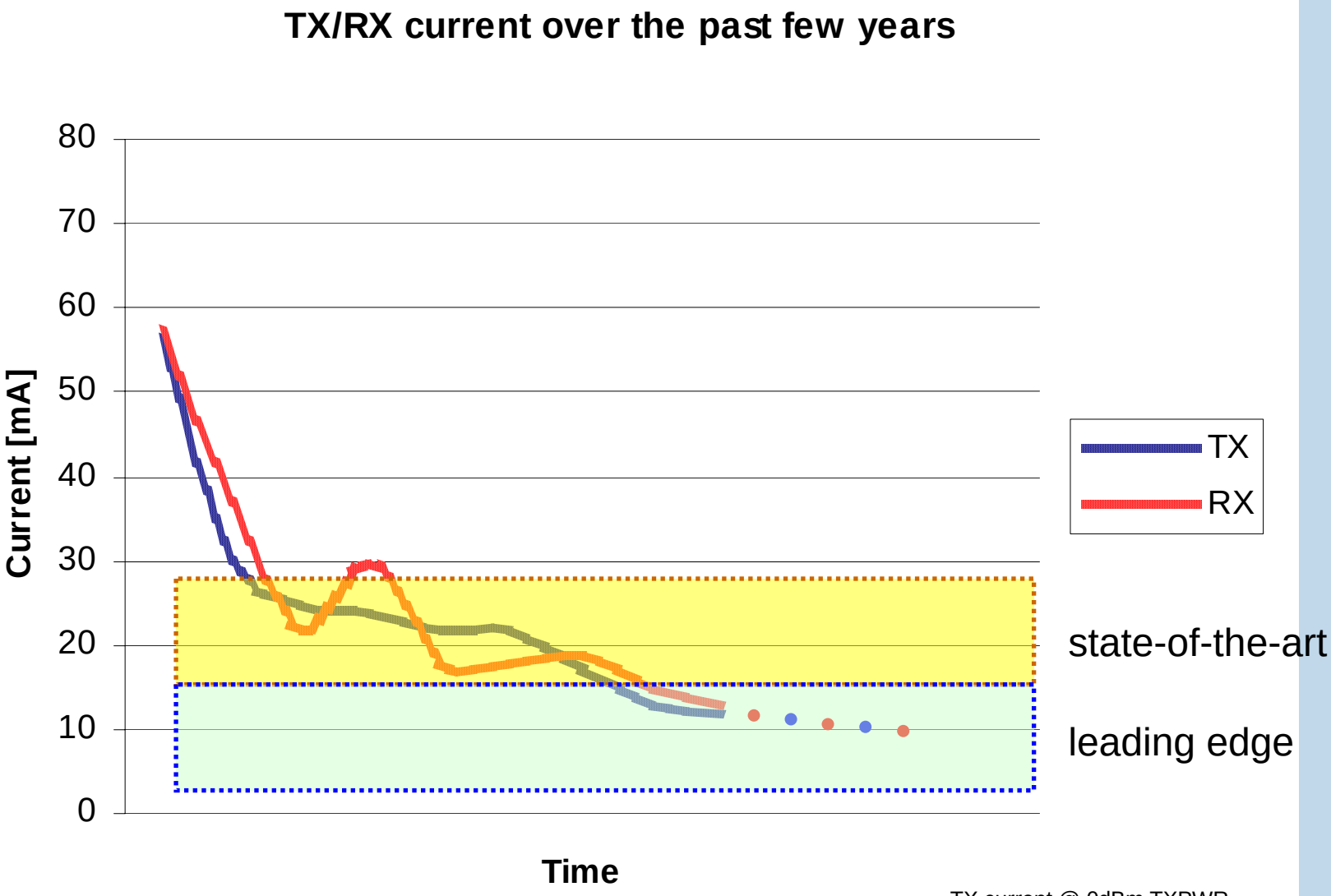
IEEE802.15.4 2.4GHz ICs (Selection)

	RF Performance		Power Consumption				
Device	Tx O/P	Rx Sens	Sleep	Inactive	Tx (0dBm)	Tx (Full)	Rx
Atmel AT86RF230*	+3dBm	-101dBm	0.02uA	1.7mA	<13mA	16mA	15mA
Atmel AT86RF231*	+3dBm	-101dBm	0.02uA	0.4mA	<12mA	14mA	13mA
TRX1*	0dBm	-92dBm	1uA	0.5mA	30mA	30mA	37mA
TRX3*	0dBm	-95dBm	20uA	426uA	17.4mA	17.4mA	18.8mA
TRX4*	+5dBm	-98dBm	<1uA		25.8mA	33.6mA	22.2mA
TRX5*	0dBm	-92dBm	<0.5uA		27mA	27mA	27mA
TRX6*	0dBm	-95dBm	2uA	?	22mA	22mA	18mA
TRX7*	0dBm	-95dBm	2uA	7.6mA	22mA	22mA	18mA
TRX8*	0dBm	-90dBm	2uA	9mA	56mA	56mA	57mA
TRX2* (SC)	+4.5dBm	-100dBm	<1uA	?	24mA	34mA	30mA

Colour coded by Linkbudget : < 95dB, 95dB-100dB, >100dB

(*) TRX parameter from datasheets available on web

Power Consumption - Trend



TX current @ 0dBm TXPWR

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RF4CE (Radio Frequency for Consumer Electronics)

- industry consortium to a RF remote control standard available for audio video consumer electronics
- the RF4CE standard is based on the 2.4GHz PHY/MAC IEEE 802.15.4 standard
- the RF4CE networking layer will be thin, flexible and future-proof
- Goals:
  - ensures **interoperability** between remote controls and audio/visual (A/V) devices
  - achieving **longer battery life** with RF remote controls
  - **coexistence** with other radio systems
  - is intended to work within a large room with many obstacles in its direct path (**extended range**)
  - …

RF4CE Performance

Performance calculations are based on 4 typical RF4CE application scenarios:

a. Energy Consumption

#1 **Button press paging**	**wake up – transactions – sleep**
#2 **Paging poll**	**wake-up – listen – sleep**

b. 24h Average Current Consumption (24 h)

#3 **Button press paging**	**50 button press and paging poll every 5 sec / 24 h**
#4 **Button press only**	**50 button press / 24 h**

- **Scenarios #1, #2 illustrating transaction power consumption**
- **Scenarios #3, #4 are determined by current drawn during sleep**

RF4CE Performance

AT86RF231 uses Basic Operation Mode

RF4CE Scenario[1]	AT86RF231+uC [2]	TI CC2430	Unit	Comments
#1	41.2	86.7	mAms	Button press power consumption
#2	18.8	32.4	mAms	Paging poll power consumption
#3	4.05	7.03	µA	With Paging: Average over 24 hrs
#4	0.29	0.55	µA	Without Paging: Average over 24 hrs

Notes

[1] Detailed description of the scenarios are in a separate documentation
http://www.embedded.com/columns/technicalinsights/209903894

[2] Figures adapted to be compatible w.r.t. the link budget

RF4CE Performance

AT86RF231 uses Extended Operation Mode

RF4CE Scenario[1]	AT86RF231+uC [2]	TI CC2430	Unit	Comments
#1	24.3	86.7	mAms	Button press power consumption
#2	18.4	32.4	mAms	Paging poll power consumption
#3	3.95	7.03	µA	With Paging: Average over 24 hrs
#4	0.28	0.55	µA	Without Paging: Average over 24 hrs

Notes

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http://www.embedded.com/columns/technicalinsights/209903894

[2] Figures adapted to be compatible w.r.t. the link budget

RF4CE Performance

- **Performance improvements are significant if devices are used which offer a better power consumption performance (cf. slide 9 & 10):**
  - **Up to** 72 % **reduction in energy consumption**
  - **Up to** 49 % **reduction in average current consumption**
- **This is based on**
  - **lower power consumption figures**
  - **faster state transitions and faster PLL**
  - **protocol acceleration techniques**

Summary

- Low data rate IEEE802.15.4 RF technology is ready for wireless sensor networks
- High link budget, low power consumption, flexible system architecture allow to fit a huge variety of system solution for low data rate applications
- There are several ways to overcome radio interference within the frequency bands used for radio communication
- Different requirements of transmission of user information and signalisation traffic will have an impact on the design of the related radio systems

Thank you very much!