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Entwicklung von Standardtests zur einheitlichen Bewertung industrieller Funklösungen (FITS)

Development of Measurement Methods for the Uniform Assessment of Industrial Radio Solutions

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Management Report

Wireless solutions for industrial applications have been used for approx. 15 years. In the course of that time essential requirements and guidelines for a successful wireless performance (e.g. coexistence management) have been developed and published (e.g. VDI/VDE 2185: Radio-based communication in industrial automation). Despite these achievements one essential demand still exists: realizing an optimal time performance with a minimum error rate at a required time.

In contrast to wire-based communication radio channels suffer from time and frequency variance and might be influenced by external interference. Multipath propagation and motion are dominant effects in industrial environments. However, parasitic machine emissions and coexisting radio systems have to be considered as well. Due to insufficient knowledge of inherent system features some radio systems are ignored or even consciously avoided. As a consequence, attractive economic possibilities of wireless industrial solutions are only partially utilized. Therefore, appropriate measurement methods for different application-specific wireless technologies are urgently needed.

Figure 1 Project logo

The goal of this research project was to develop appropriate standard test cases for a unified evaluation of the time and error performance of industrial wireless solutions with respect to selected classes of industrial applications. Especially, the following issues were addressed:

- Improve product assessment with validated methods and models.
- Support quality management by systematic approaches.
- Support realization of reliable wireless systems.
- Avoid unprofitable investment.

Fundamental parameters for time and error assessment such as transmission and update time, packet error rate and availability were derived as basic prerequisites. The 95 % percentile for transmission time and the standard deviation for update time were selected as appropriate statistical time measures.

Next, application profiles and related test cases were specified (Table 1). Additionally, the environment 'elevator shaft' was included as a special application. These profiles and specifications were defined in consequence of several discussions with companies of the GMA working Group `Radio Based Communication´ and the ZVEI working group `Wireless Automation´ that were either actively involved or interested in this project.

Table 1 Application profiles (NLOS/OLOS: non-/obstructed line of sight)

Influencing parameter (application related)	**Machine**	**Factory hall**	**Process plant (indoor)**	**Process plant (outdoor)**
Number of communication devices	16	50	100	100
Spatial dimension of the communication system (L, W, H) in m	10, 5, 5	100, 25, 10	100, 25, 15	500, 500, 15
Distance between communication devices	10 m	100 m	100 m	700 m
Motion of the communication devices	0 m/s, 5 m/s	1,5 m/s	0	0
User data length	2 Byte	64 Byte	20 Byte	20 Byte
Initiation of data transfer	periodic	periodic	periodic	periodic
Transmission interval	100 ms	250 ms	4 s	4 s
Intervisibility	NLOS	NLOS	NLOS, OLOS	NLOS, OLOS
Other radio communication systems	WLAN	WLAN	WLAN	WLAN
Location of application area	indoor	indoor	indoor	outdoor

Based on representative measurements in real environments appropriate model descriptions and test procedures were developed for these standard test cases. Both were verified with validation and trial measurements.

Fig. 2 shows the prototype test set-up. A real-time channel emulator connected to two shielded test boxes can be seen at the bottom of Fig. 1. The radio devices under test (DUTs) need to be placed within these test boxes. The top part shows the PC for controlling, management and evaluation purposes. Further required measurement devices (multi-face devices, protocol analyzer, vector signal generator, real-time spectrum analyzer) can be seen in the center.

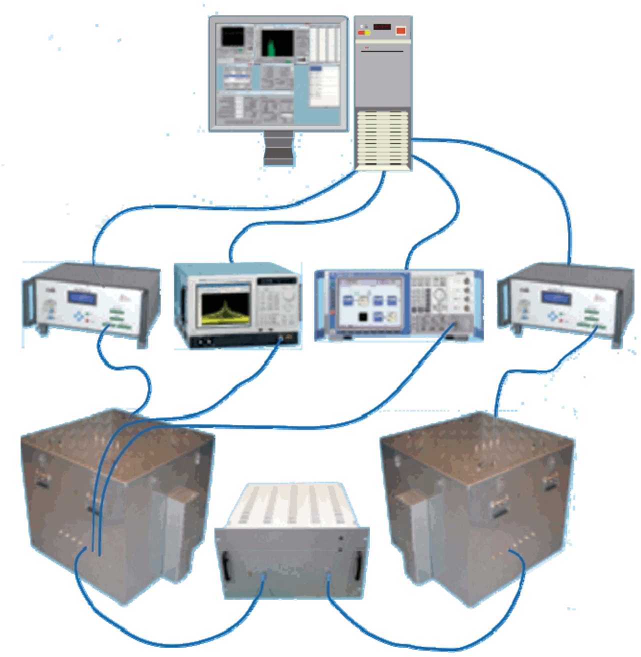

Figure 2 Prototype test set-up

The development of the model descriptions started with high-frequency radio channel measurements in the real environment. Next, appropriate parameters for real-time channel emulation were derived. These model descriptions were verified with validation measurements (fundamental time and error parameters) of the radio systems in the real environment and compared to measurements with the channel emulator in the lab. Table 2 shows exemplary results for the standard test case 'factory environment'. In the lab it could be acknowledged that all measurements of the standard test cases can be realized with emulated test measurements.

The successfully developed test procedures of this research project enable manufacturers to evaluate the application-specific performance of their wireless systems in an early stage of development. Due to the fact that emulator-based test procedures are deterministic and thus reproducible, manufacturers can perform comparison measurements between different hardware and software versions. In real environments this is not possible.

We propose the performance classes A, B, and C (see logo in Fig. 1) with additional information concerning total and time-dependent availability (Table 3). This enables manufacturers and customers to develop and select an optimal wireless solution for specific application areas.

Table 2 Comparison of transmission time (top row) and update time (bottom row) for Bluetooth communication in a factory hall. Left column: real environment, right column: lab test with channel emulation (link margin 6 dB, no interferer)

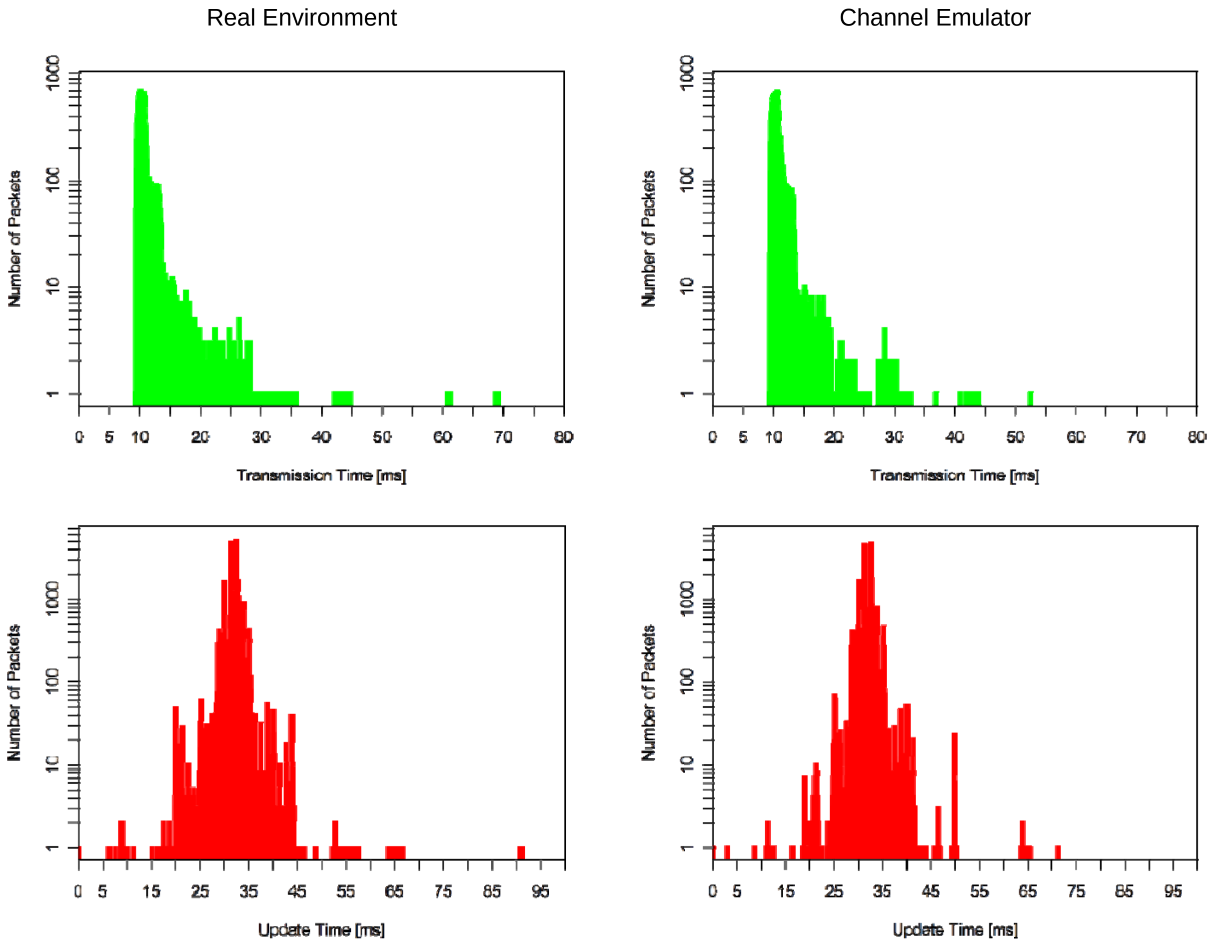

Table 3 Exemplary results of different standard test groups (TG) and test cases (TC). TT: transmission time, UT: update time, SD: standard deviation

Standard TG name	Standard TC name	TT		UT		Performance class		
		Mode	P95	Mean	SD	Symbol	Time	Availability
Machine	Standard	35,7	45,9	100,4	16,9		C	99,52%
Machine	Interferer	15,8	18,9	40,0	3,4		A	100,00%
Factory hall	Standard	10,2	12,8	32,0	1,6		C	100,00%
Factory hall	Standard	0,3	2,4	31,9	2,1		A	99,96%
Factory hall	Interferer	0,3	2,5	33,0	6,0		B	97,92%
Factory hall	Standard	0,4	0,6	32,0	0,3		A	100,00%
Factory hall	Interferer	0,6	4,2	32,2	6,7		C	99,53%
Factory hall	Interferer	0,5	3,6	32,0	5,0		B	99,94%
Process plant	Indoor - Movement	23,2	25,0	50,2	4,8		A	99,96%
Process plant	Indoor - Movement	22,6	24,7	53,5	124,5		C	96,01%
Special	Standard	0,4	0,5	10,0	0,2		A	100,00%
Special	Standard	10,7	28,1	50,0	11,5		A	100,00%

Results of this research project have been and will be further published. Apart from publications in journals and on conferences the developed 'application classification' was announced in June 2010 to be included in the international document 'IEC SC65C WG 17 - Wireless Coexistence'. Additionally, 'coexistence related data sheet parameters' were specified and included in the international document 'IEC Draft Technical Specification IEC/DTS

62657: Industrial Communication Networks - Wireless Communication Network and Communication Profiles - Wireless Coexistence' in October 2010.

In order to put the project results on a broader basis, the developed measurement methods shall be established as industrial standards. In March 2012 the GMA working group 'Radio Based Communication' of the VDI/VDE association 'Measurement and Automation (GMA)' launched a call for participation in the project 'Measurement Based Performance Evaluation of Wireless Solutions for Industrial Automation Applications'. Results shall be published as guidelines following the VDI/VDE guideline 2185 'Radio Based Communication in Industrial Automation'. This guideline is aimed at manufacturers of industrial wireless solutions, planning persons and operators of industrial wireless applications, suppliers of wireless technologies, and standardizing bodies for industrial and wireless communication. The green print shall be published in 2013 on the occasion of the Hanover Exhibition.

The research project was performed in close co-operation with the GMA working group 'Radio Based Communication' of the VDI/VDE association 'Measurement and Automation (GMA)' and the ZVEI working group 'Wireless Automation'.

All goals of the research project have been successfully met.

The final report (in German) is available from:

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