IP500 as ‘THE’ IoT infrastructure for a smart world

IP500 Performance Results

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Introduction.

IP500 – Test.

Test environment and benchmark settings

- In extensive tests under real conditions, the companies DAFÜR in Darmstadt and umlaut in Aachen together with the Leipzig University of Applied Sciences (HTWK Leipzig) have tested the properties and performance of IP500 technology. The aim was to verify potential advantages for particular IoT use cases and applications.
- Test results have proven that IP500 as an IoT radio platform combines and fulfils the required characteristics: security, robustness and high performance as the most promising candidate for industrial applications and commercial buildings.
- Following slides will provide more details about methodology and insights into independent test results.

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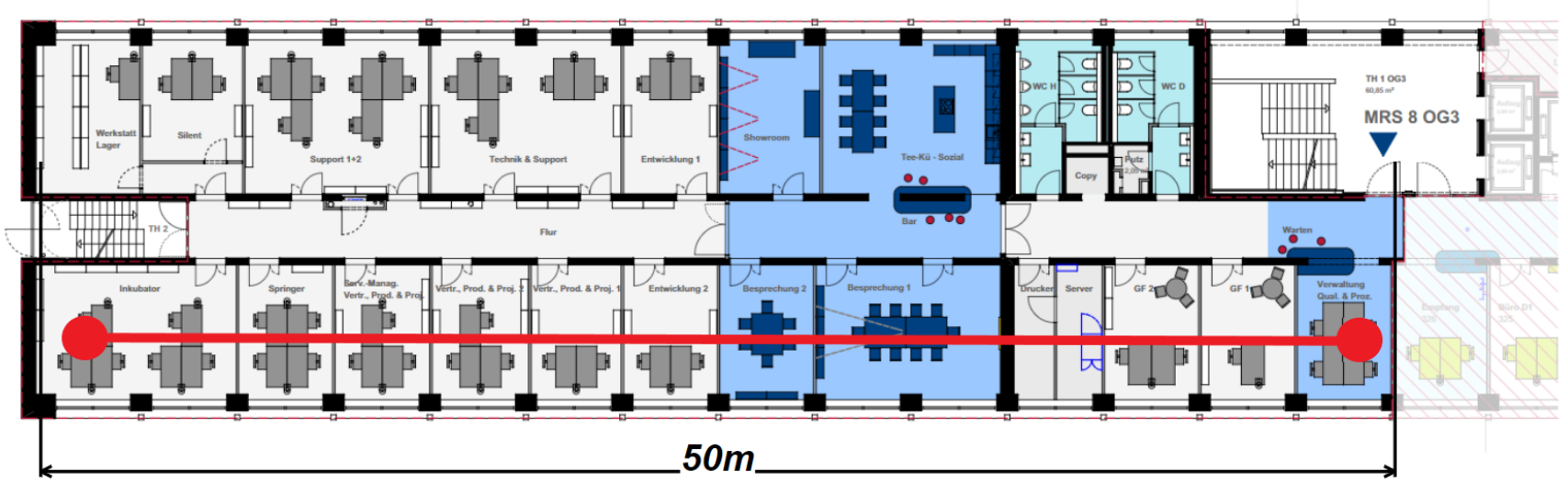
IP500 latency and coverage performance.

IP500 – Indoor Coverage Test.

Test environment and setup

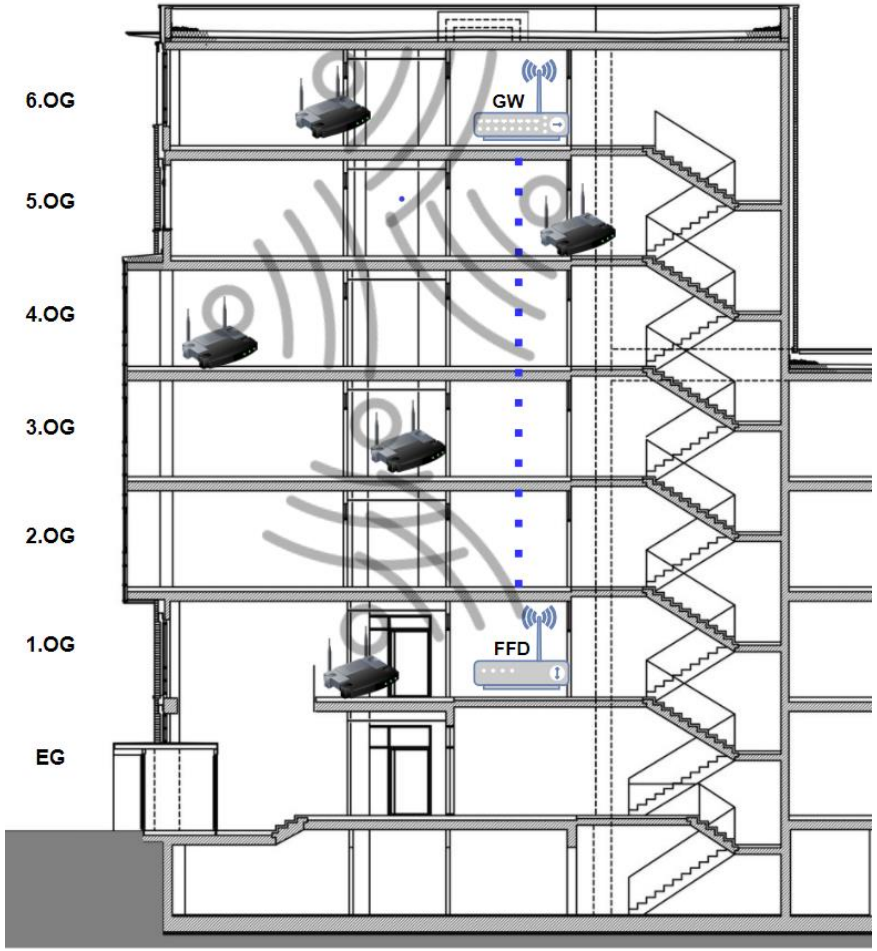
- DAFÜR test environment:
  - Office environment, horizontal coverage of **50 meters** from node to node through 12 walls including 2 of reinforced concrete over 20 WLAN networks and other interferences.
  - Maximum range could not yet be exhausted due to limited floor length.



IP500 – Indoor Coverage Test.

Test environment and setup

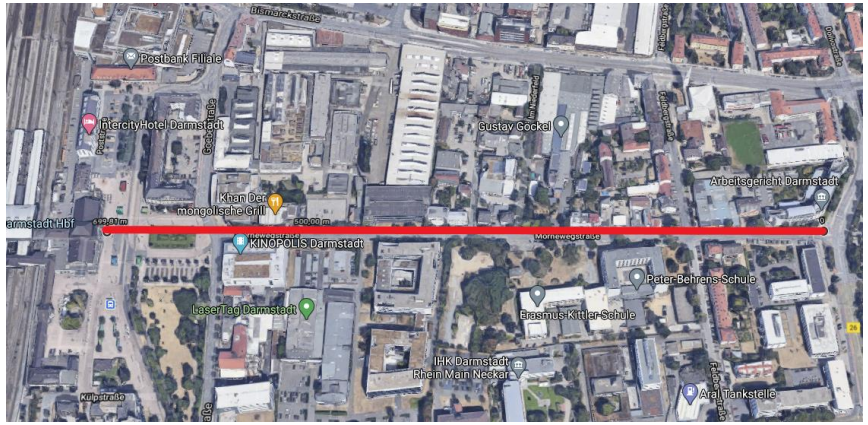
- DAFÜR test environment:
  - In the same environment, a vertical coverage of six floors was achieved. This involved **covering 5 reinforced concrete ceilings**, each about 25 cm thick.
  - Antennas with higher gain tend to achieve better range. This assumption shall be confirmed by further measurements in larger and higher buildings.



IP500 – Outdoor Coverage Test.

Test environment and setup

- DAFÜR test environment:
  - For intra-city measurements, a street in downtown Darmstadt was chosen that runs between commercial and residential buildings.
  - For countryside measurement, a straight concrete road was chosen in the agricultural area between fields, 2 km away from the next population.
  - depending on frequency, coverage ranges from
    - **600 m** inner-city up to
    - **1,200 m** countryside
  - For both measurements, the Node Connect Gateway (NCG) was fixed to the vehicle at a height of two meters.



IP500 – Latency Performance.

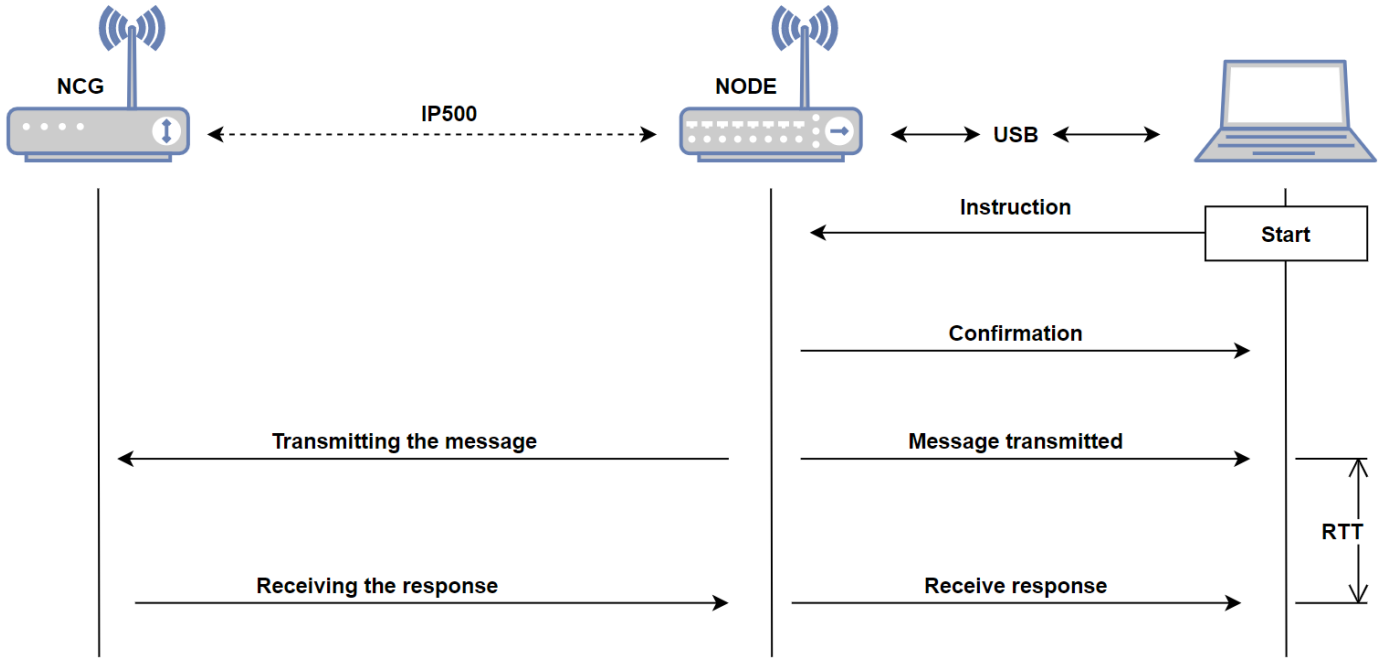
Test environment and setup

A latency time below 50 ms is of crucial importance for **time-critical applications**, such as light switching or access control, via the wireless network.

As a next step, the routing of the IP500 network was thus tested to evaluate the latency time.

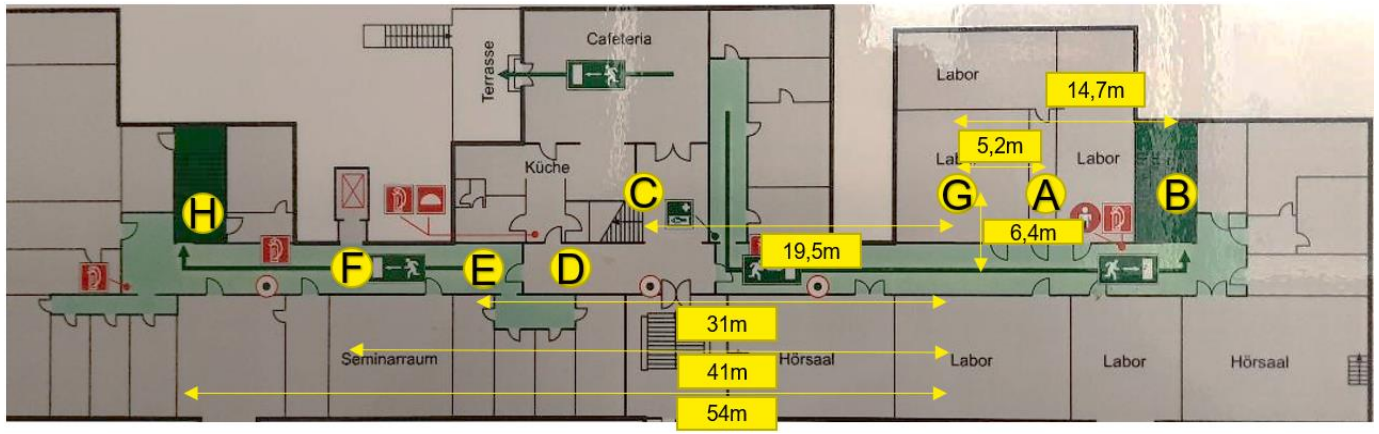
Also in this test, the IP500 network delivered outstanding results:

- Latency was measured with
  - **11 ms** at 2,4 GHz and
  - **33 ms** at 868 MHz frequency.
- Depending on topology, value above multiplied by number of nodes gives the total time.



IP500 – Indoor Coverage Test.

Test environment and setup

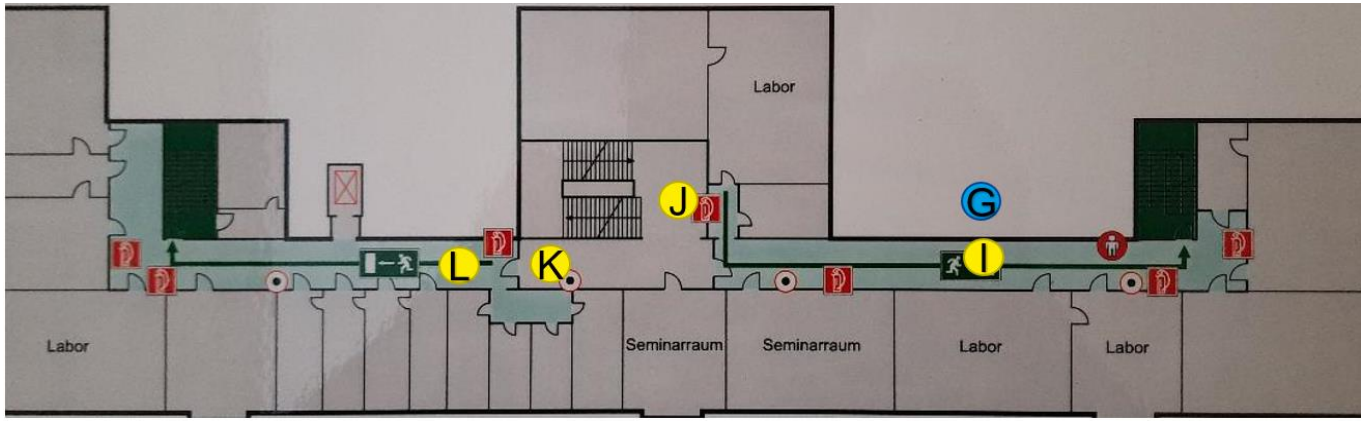


Location	A	B	C	D	E	F	H
Floor	0	0	0	0	0	0	0
Distance from NCG [m]	5,3	14,2	19,0	27,8	32,7	41,0	52,2
IP500 Auto	10	10	10	10	10	10	0
IP500 868 MHz	10	10	10	10	10	10	0
IP500 2,4 GHz	10	10	10	10	0	0	0

Number of received telegramms from 10 sent telegramms with an ERP of 14 dBm

IP500 – Indoor Coverage Test.

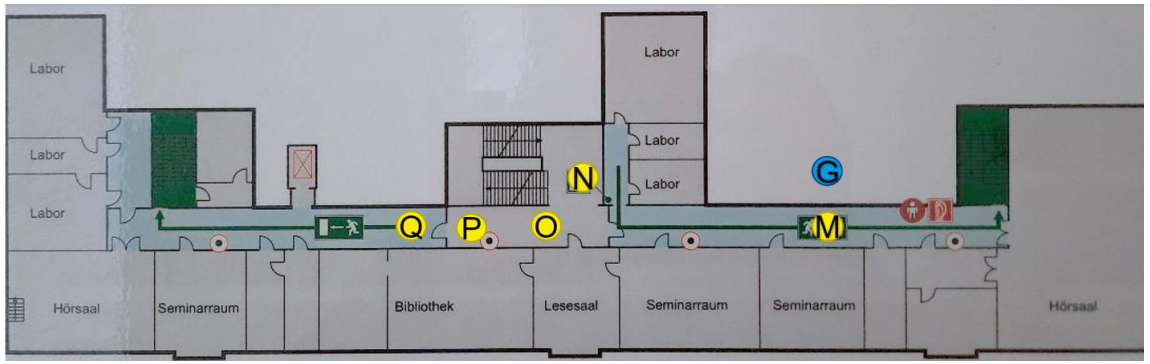
First floor



Location	I	J	K	L
Hight [m]	5,7	5,7	5,7	5,7
Floor	1	1	1	1
Distance from NCG [m]	8,6	19,8	28,4	33,1
IP500 Auto	10	10	9	0
IP500 868 MHz	10	10	9	0
IP500 2,4 GHz	10	10	9	0

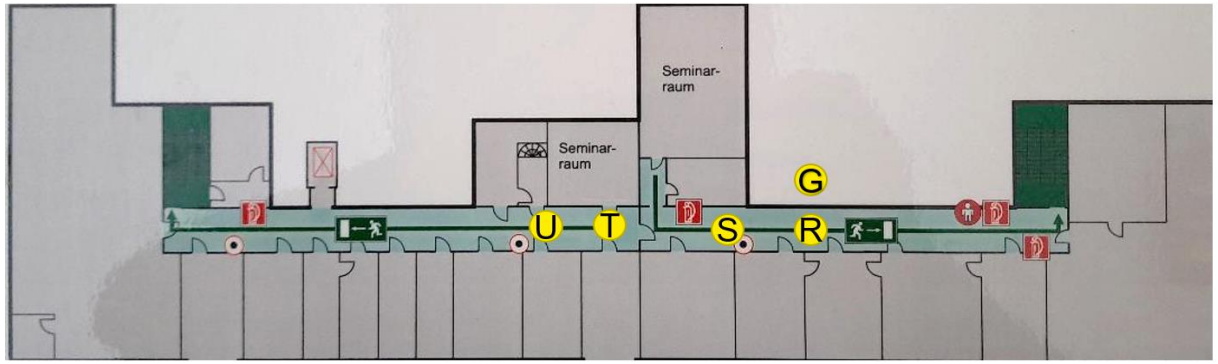
IP500 – Indoor Coverage Test.

Second floor



Location	M	N	O	P	Q
Hight [m]	11,4	11,4	11,4	11,4	11,4
Floor	2	2	2	2	2
Distance from NCG [m]	13,1	22,2	25,6	30,9	35,5
IP500 Auto	10	10	10	9	0
IP500 868 MHz	10	10	9	9	0
IP500 2,4 GHz	10	9	9	9	0

Third floor



Location	R	S	T	U
Hight [m]	17,1	37,05	17,1	17,1
Floor	3	3	3	3
Distance from NCG [m]	18,3	39,2	26,4	31,0
IP500 Auto	10	10	10	0
IP500 868 MHz	9	10	10	0
IP500 2,4 GHz	10	10	0	0

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IP500 Robustness.

IP500 – Robustness Test.

Test environment and benchmark settings

- umlaut test environment:
  - umlaut used a flexible RF solution which provides a “real size” environment for RF related testing.
  - For this project, a canopy in the dimension of an aircraft cabin has been built up with the goal to test best performing technology in terms of robustness and tolerance to interference.
  - Goal was to simulate user data traffic via different technologies in interfered environment, in order to understand which technology provides best performance.
- Benchmark settings and definitions:
  - 88-byte packet has been sent every 100ms.
  - The distance between sender and receiver has been defined with 12 meters via direct RF link.
  - For every test case successful reception of 3.000 packets was set as a target.

IP500 - Robustness Test.

Test environment and benchmark settings

- Benchmark settings and definitions:
  - 88-byte packet has been sent every 100ms.
  - The distance between sender and receiver has been defined with 12 meters via direct RF link.
  - For every test case the successful reception of 3.000 packets was set as a target.
- Three Wi-Fi interference scenarios have been defined:
  - Scenario 1: airtime utilization of 70 – 70 – 30 (for Wi-Fi channel 1, 6 and 11)
  - Scenario 2: airtime utilization of 10 – 10 – 30 (for Wi-Fi channel 1, 6 and 11)
  - Scenario 3: airtime utilization of 70 – 10 – 30 (for Wi-Fi channel 1, 6 and 11)

IP500 - Robustness Test.

IP500 vs. SmartMeshIP results.

- Direct comparison between IP500 and SmartMeshIP reveals that Packet Error Rate (PER) value of IP500 is lower with more devices being active.
- Overall Packet Error Rate performance of IP500 is much better compared to other technologies.
- In the context of SmartMeshIP, PER significantly increases with growing number of active Bluetooth devices for all three interference scenarios.

Summary & Conclusions.

IP500 – Radio network for IoT in smart cities and smart buildings.

- A radio-based IoT networking of sensors and actuators could not be realized on a large scale in commercial buildings so far. The reason for this was that certain conditions had to be created first.
- If we look at the entire IoT wireless network, security, robustness and redundancy can be divided into three areas:
  - the physical radio layer (frequency, band and modulation),
  - the networking layer (network topology, routing, encryption) and
  - the infrastructure (IoT platform, IoT gateway, database structure, repeaters, wired devices i.e. switches).
- Compared to other wireless networks, IP500 scores with the following advantages:
  - high range of coverage,
  - low energy consumption,
  - high security in the transmission,
  - superior robustness,
  - low overall latency performance allowing high number of sensors as part of the solution,
  - low infrastructure costs due to continuous scalability

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