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The last session of the conference:

# Lessons Learned During the Implementation of the BVR Wireless Sensor Network Protocol on SunSPOTs

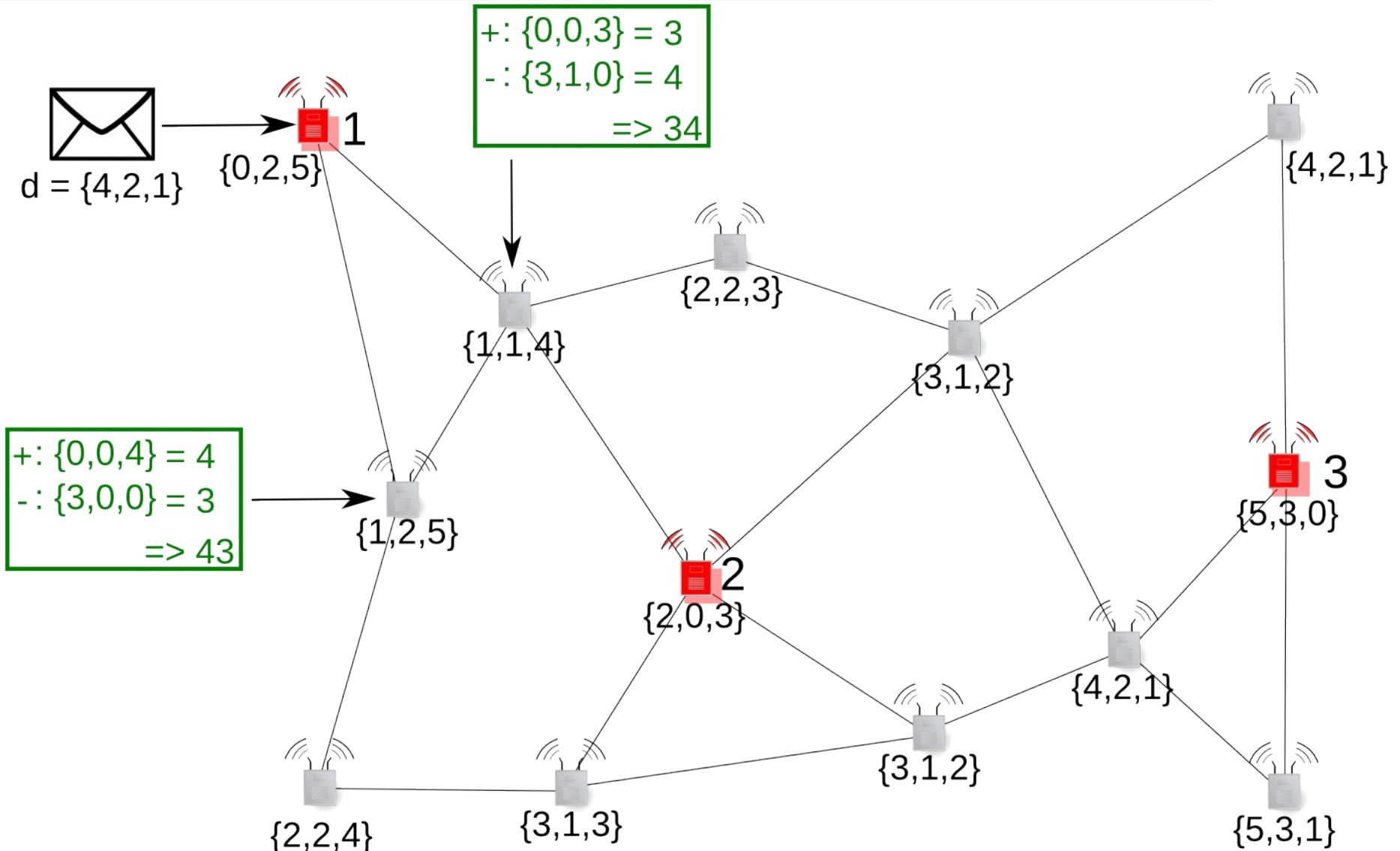
From: Ralph Erdt

# Topics

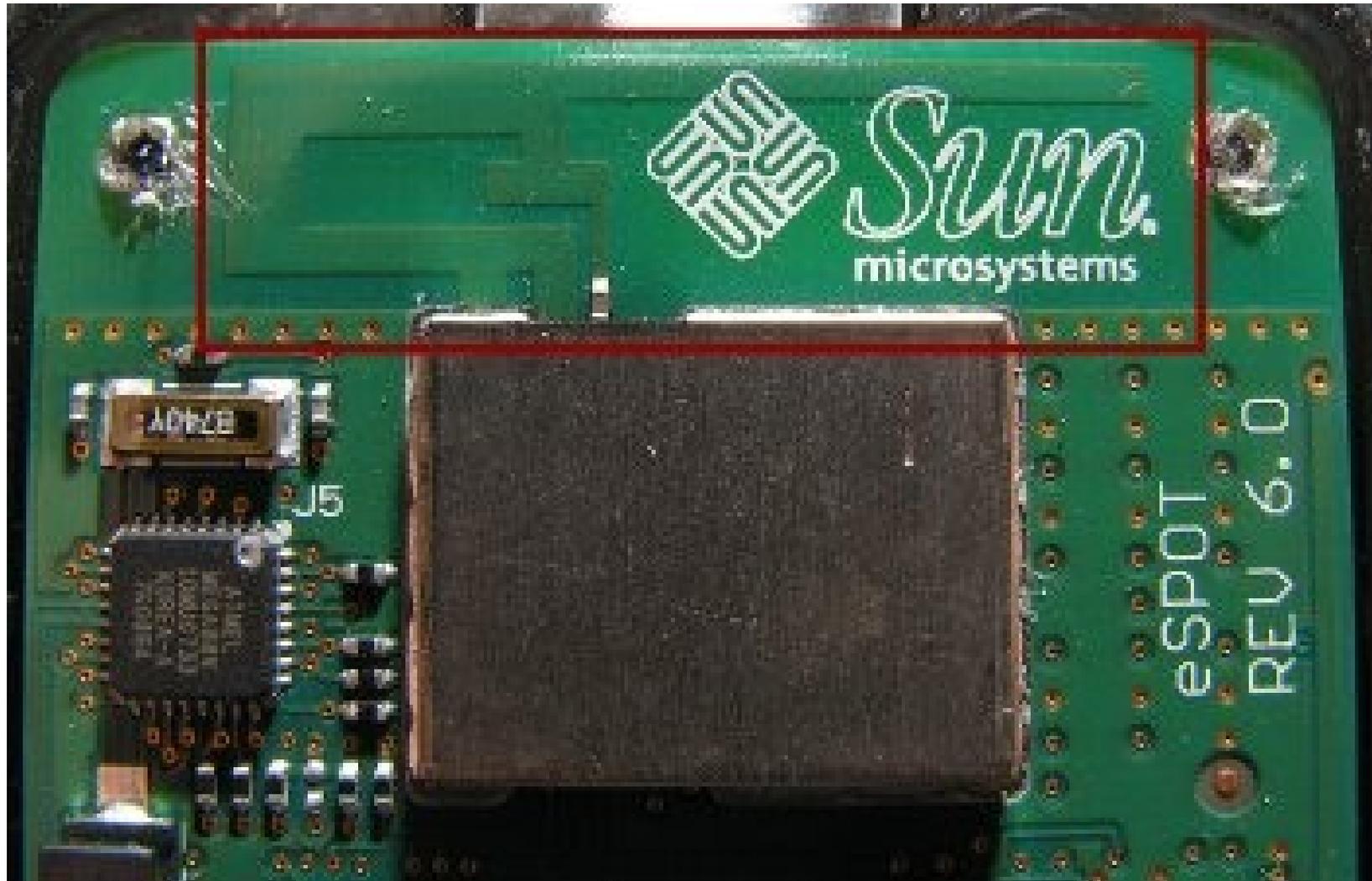


- BVR (very) short
- „Inverted F“ Antenna
- Issues:
  - Signal strength by distance
  - Signal strength by rotation
  - Conclusion
  - Influences on BVR
- Solutions
- Outlook

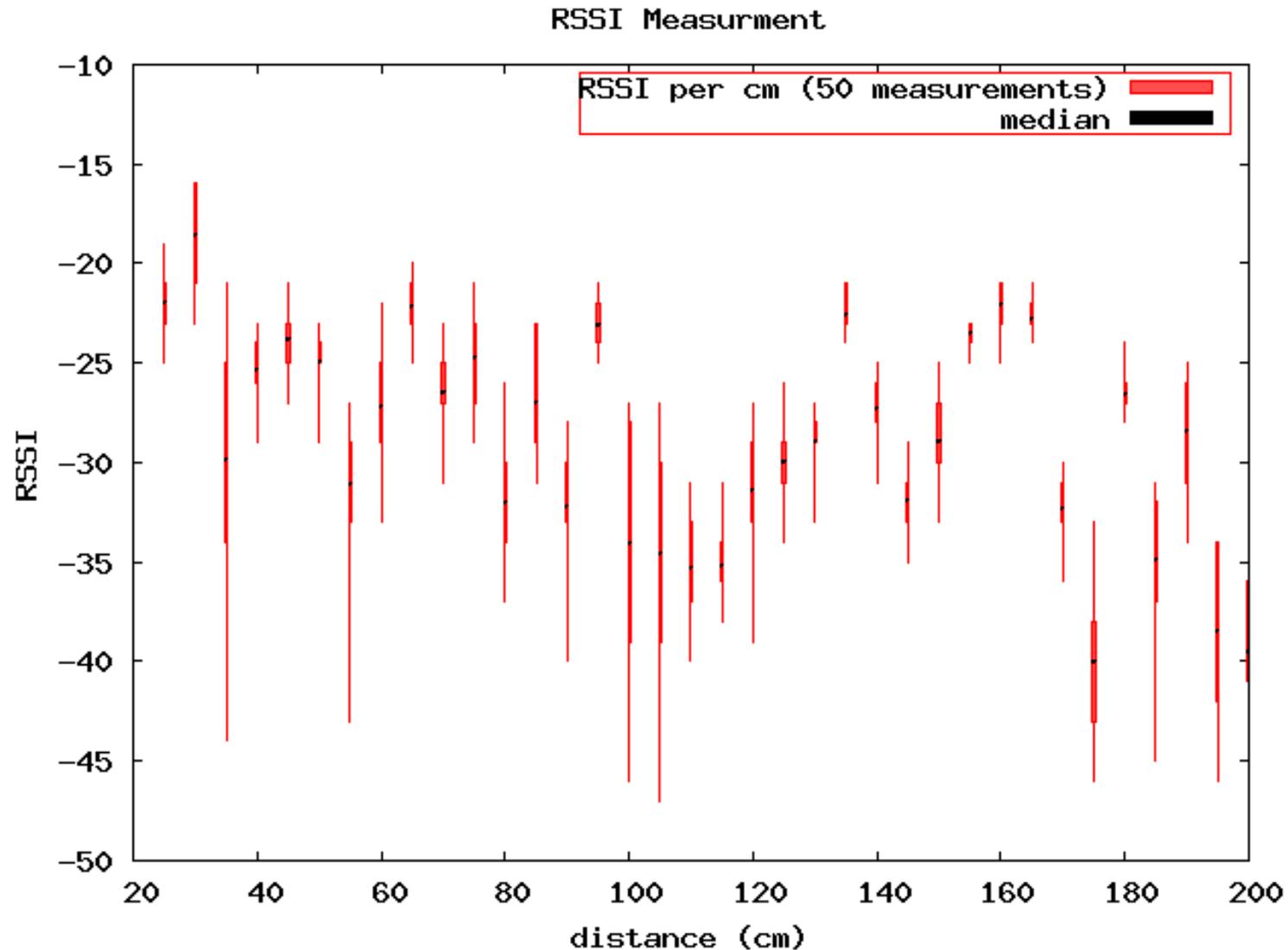
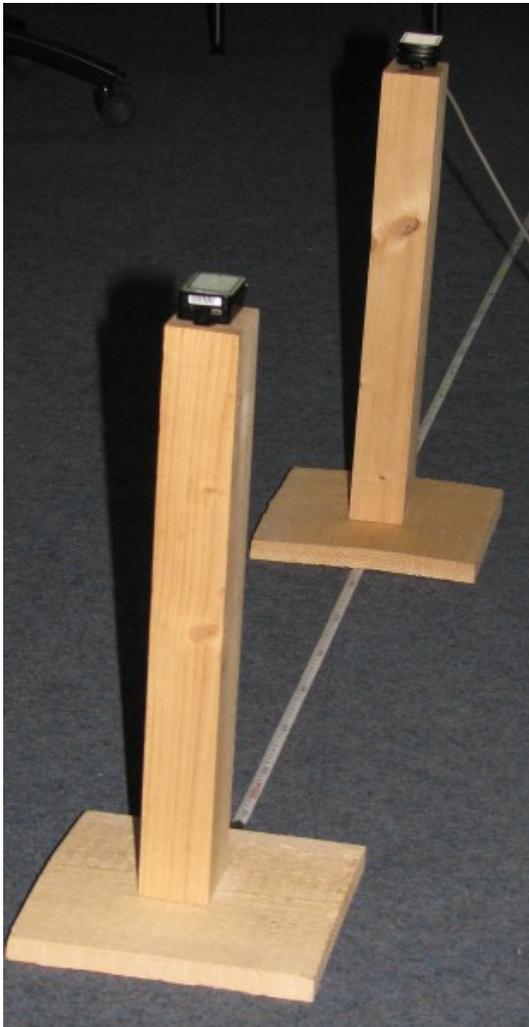
# BVR (very) short



# „Inverted F“ Antenna



# Signal Streng by Distance



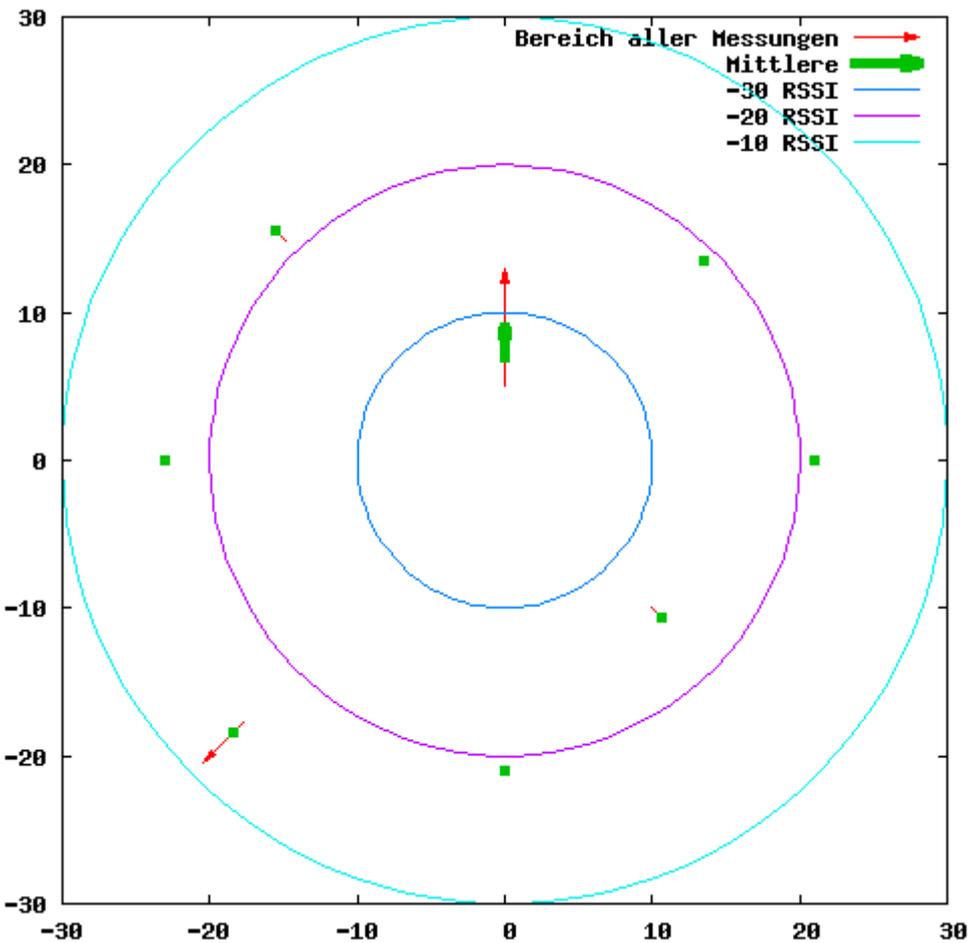
# Signal Strength by Rotation



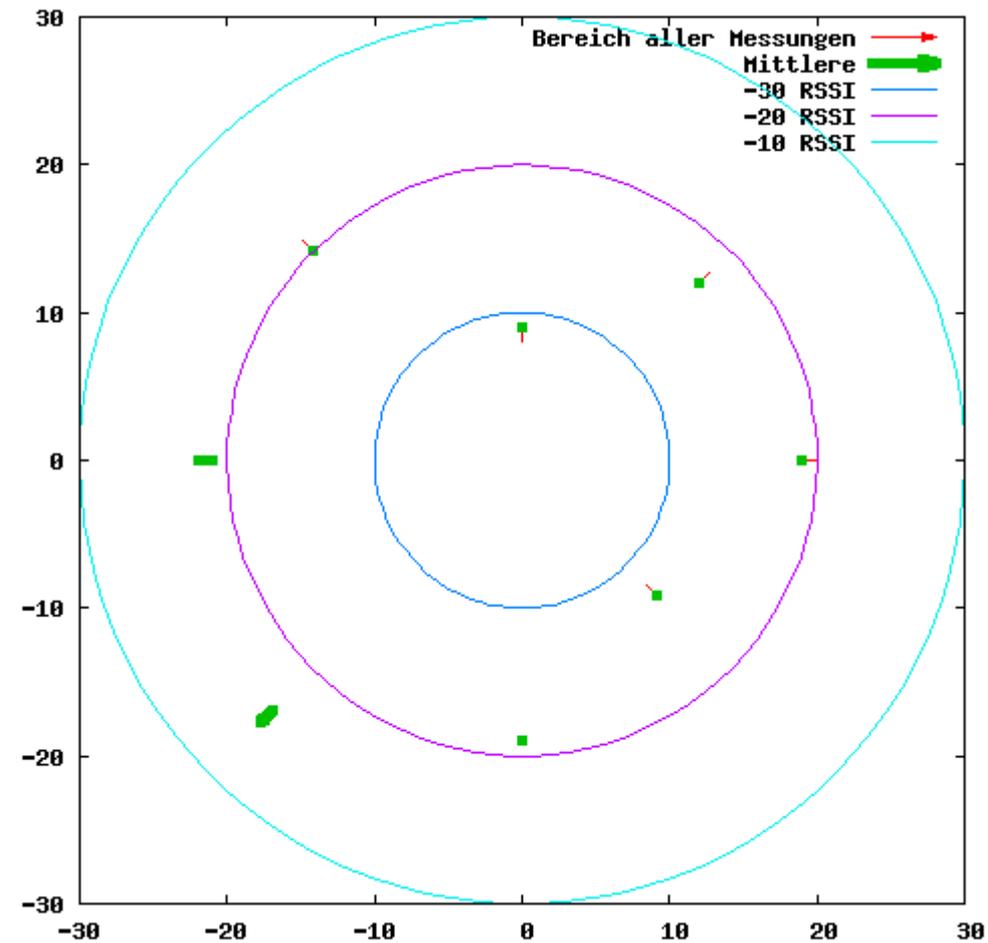
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# Signal Strength by Rotation



Sending



Receiving

# Conclusion of Signal Strength

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- Signal strength is very variable,  
not deterministic like in theoretic physic
- Difference between sending and  
receiving signal strength

# Influences on BVR



- Assumption of stable and bi-directional communication is invalid
  - Neighborhood is not possible with the BVR way „one station sends, the receiving stations accept“
  - Beacon will be flooded „away“ from the beacon node – sending in direction will not work properly
- (This is not an BVR specific problem!)

# Solutions



- BVR:
  - Make statistics and send them with the neighborhood
  - In „implementation section“ - why not in protocol definition?
- Our solution (easy way)
  - Varying signal strength: Threshold
  - Uni-directional Links: Two way messages

# Analysis



- Two-way messages: More Messages, than in definition.
- But.. why not using uni-directional Links?
- Why n:m?

# Outlook

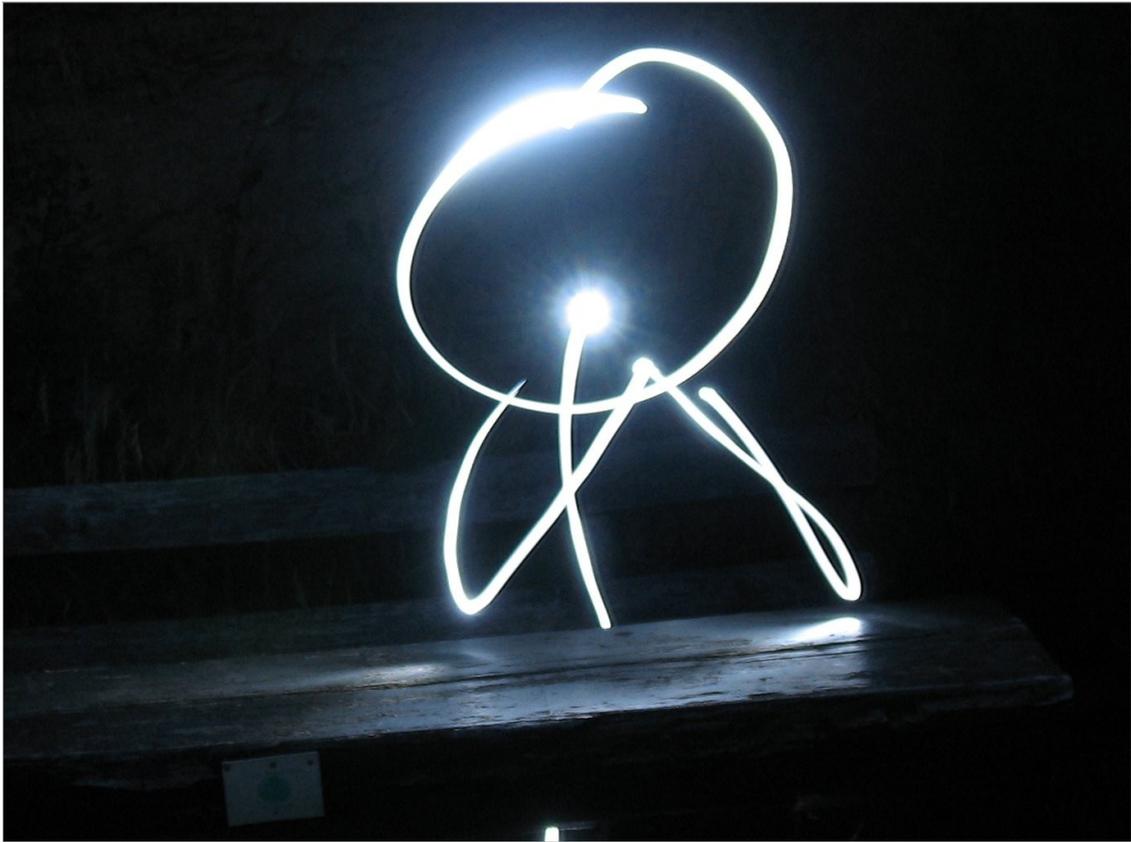


- Master theses at HSRM (Germany)
  - Reduced functionality to all-to-some (collectors)
    - Reduced complexity
  - Using uni-directional links, to save hops
  - To discover those links, use local flooding (over n hops)
  - Even using local flooding, fewer packets will be needed.



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Thank you for your attention



Titel durch Klicken hinzufügen



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Lessons Learned During the Implementation of the  
BVR Wireless Sensor Network Protocol on  
SunSPOTs

From: Ralph Erdt

Lessons Learned During the Implementation of the  
BVR Wireless Sensor Network Protocol on SunSPOTs

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Hello and welcome to the last session of this conference.

My name is Ralph Erdt, and I am from the University of Applied Sciences, Wiesbaden Rüsselsheim Geisenheim.

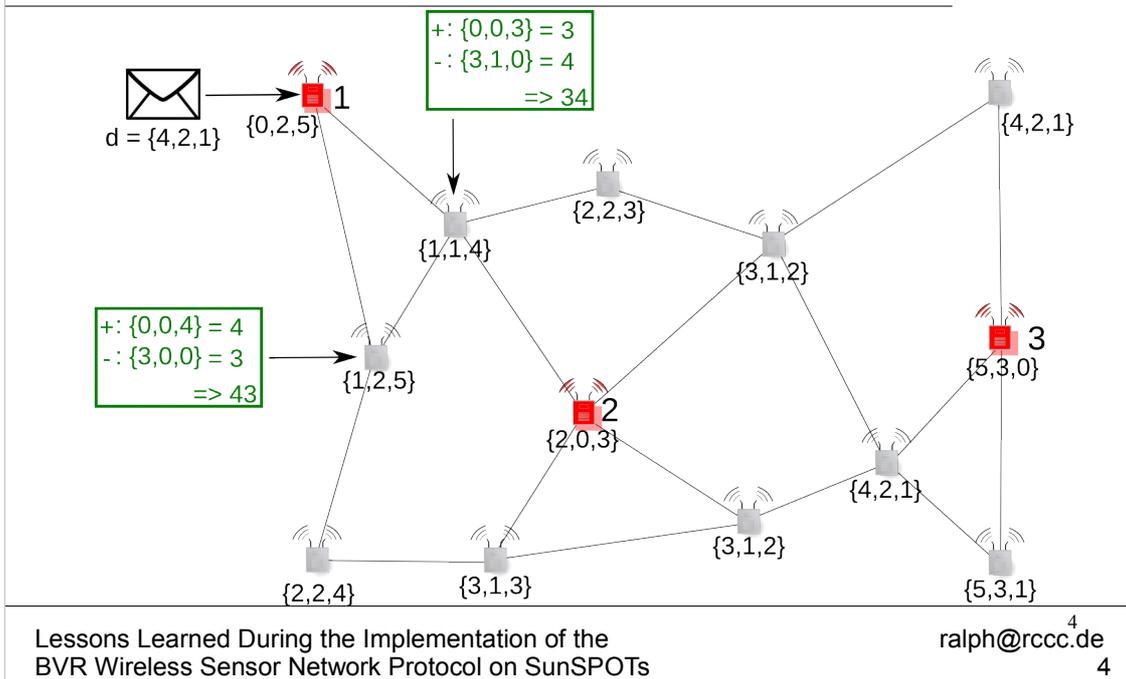
In a 10cp point lesson in my study, we have implemented the BVR protocol on SunSPOTs. In this talk, I want to show and demonstrate a few problems.

# Topics



- BVR (very) short
- „Inverted F“ Antenna
- Issues:
  - Signal strength by distance
  - Signal strength by rotation
  - Conclusion
  - Influences on BVR
- Solutions
- Outlook

# BVR (very) short



BVR defines  $r$  beacons.  $R$  nodes will promote themselves as beacon. Every beacon flood a beacon packet in the network. This packet has a hopcounter, and every node resending the packet increments the counter.

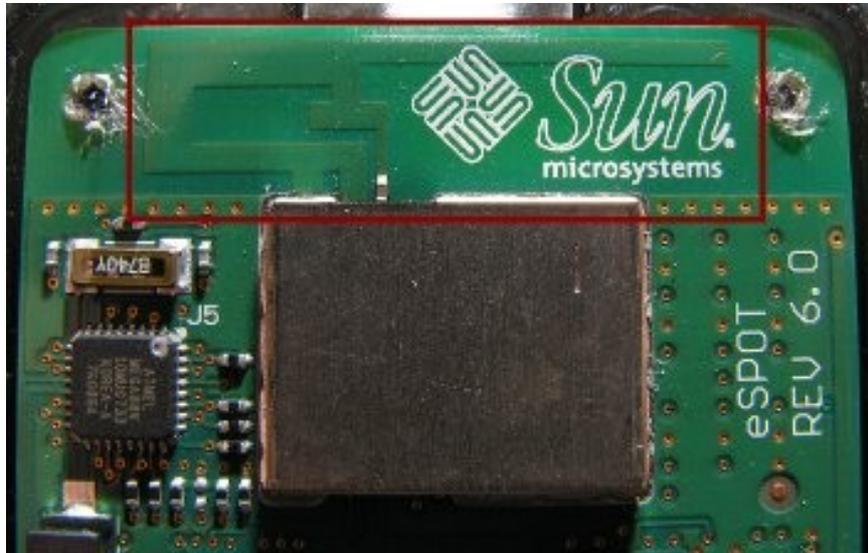
After flooding all beacon packets through the network, every node learns the "hop-distance" to all beacons.

The set of this distance is called „beacon-vector“ and it is used as routing address.

To recognize the nodes in range, every node send periodically his address, and every receiving nodes know this is neighbor.

If a packet has to be routed, the nodes compares the target address with every neighborhood address and send the packet to the neighbor with the lowest difference.

## „Inverted F“ Antenna



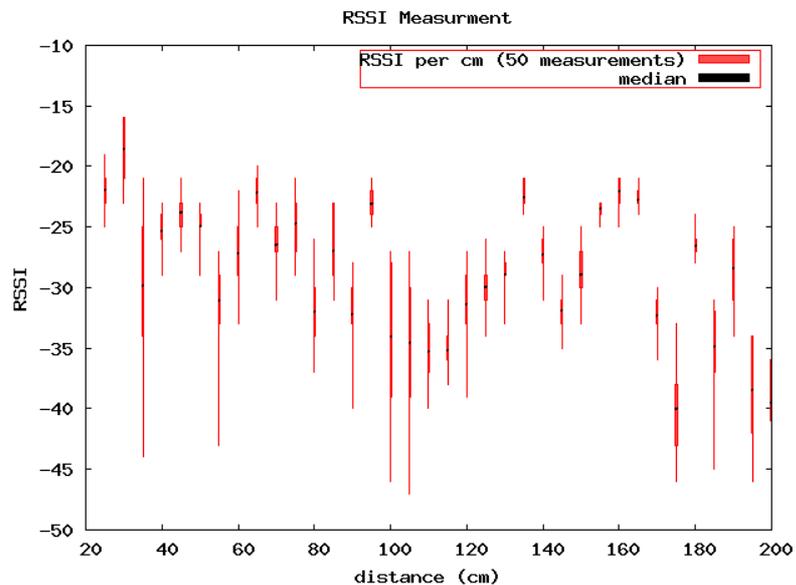
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BVR and many WSN protocols are based on bi-directional and stable communication links. But is this given?

The picture is a foto of a SunSPOT antenna. This is the printed circuit over the metal shield This is the well know and IP free „inverted F“ layout. This antenna isn't symmetric and far away of an ideal isotropic antenna. Does this have any influence on the communication? The test this, we made a few tests.

# Signal Streng by Distance



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At first, we tested the signal strength over the distance.

Do do this, we placed two SunSPOTs on wood-thrums (so, the Fresnel zone is free). We measured every 5 cm, beginning with 25 cm up to 5 m. Per measurement, we send 50 packets, an noticed the signal strength. This strength in this figure is in „RSSI“, what stand for „Received Signal Strength Indication“. This is a raw-value given by the hardware. But the scale, SunSPOT is using, is the the same as dB.

As you see, there are many distances, where the singal strength have a significant variance. So, there are positions, were the a few packets have a good stregh, an other packets can be lost. So, the communication is not stable.

## Signal Strength by Rotation

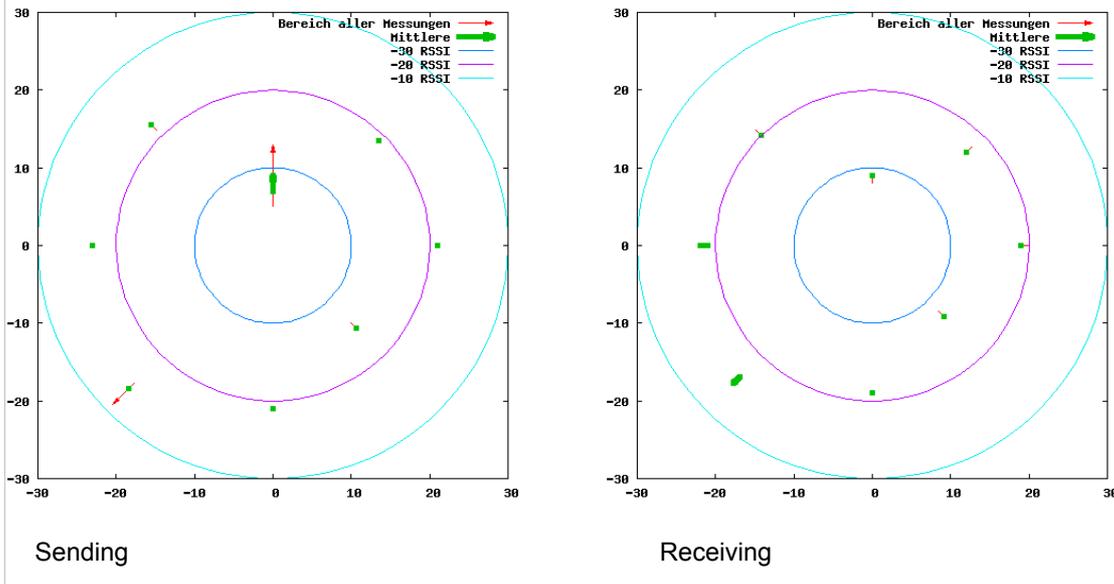


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A additional test, we measured the signal strength depending of the rotation. To do this, we fixed a SunSPOT under a rotating dish. In front of this, a second SunSPOT. In every 45° angel, the second SunSPOTs sends 50 packets. The first receives them, measured the strength and when all 50 packets are received, they will be send back with the measured signal strength. The second SunSPOT measured this packets too, and reports both stength.

# Signal Strength by Rotation



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This are the results. Left, the signal strength measured by the second SunSPOT (the rotary Spot sends), left the receiving strength (by the rotary Spot).

Its clearly visible, that the signal strength in different directions varies. At 225° there is the best receiving/sending strength, and at 90°, the worst. But does this matter. No. Because, the sending and receiving strength will be added. And even, if the backway is less powerfull, the receiving amplification will compensate this.

But, if you take a close look, for example at 0°, the dot on figure „sending“ is upper the circle, and in figure „receiving“ is lower the circle. This difference is about 2dB in all directions. So, it can happen, that in one direction a packet will be received, but not, when sending back. The communication is directional! This was observed by many groups.

## Conclusion of Signal Strength



- Signal strength is very variable, not deterministic like in theoretic physic
- Difference between sending and receiving signal strength

So, the assumptions of many WSN protocols (even BVR), that the communication is stable and bi-directional, is not given.

# Influences on BVR



- Assumption of stable and bi-directional communication is invalid
  - Neighborhood is not possible with the BVR way „one station sends, the receiving stations accept“
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- (This is not an BVR specific problem!)

# Solutions



- BVR:
  - Make statistics and send them with the neighborhood
  - In „implementation section“ - why not in protocol definition?
- Our solution (easy way)
  - Varying signal strength: Threshold
  - Uni-directional Links: Two way messages

We have tried to implement the protocol as given, without a look at the „implementation“ section in the paper. But this did not work, so we implemented these work-arounds

# Analysis



- Two-way messages: More Messages, than in definition.
- But.. why not using uni-directional Links?
- Why n:m?

Our solution needs more packets than the BVR solution, but it is easier to service (KISS).

But – why not using these unidirectional links? With unidirectional links, we can send farther, than with bidirectional links. And it will save messages.

And a second one: Why are sensor network protocols n to m? Why have every sensor talk to every other sensor? Did the light sensor relay need to send messages to the temperature sensor?

# Outlook



- Master theses at HSRM (Germany)
  - Reduced functionality to all-to-some (collectors)
    - Reduced complexity
  - Using uni-directional links, to save hops
  - To discover those links, use local flooding (over n hops)
  - Even using local flooding, fewer packets will be needed.

At the University of Applied Sciences, Wiesbaden Rüsselsheim Geisenheim, there is a master thesis finished, which created and measured a WSN protocol. This protocol pay attention to all observed problems.

The reduction of the network type to „all nodes to some collector node“ leads to a significant reduced routing complexity.

Additionally, the protocol is successfully using uni-directional links. It uses local flooding to to detect uni-directional links. Even this will cause a higher initial network load, after a short time, it will have an advantage.

Titel durch Klicken hinzufügen



Thank you for your attention

Thank you for reading this.

If you have any questions, feel free, to write me an  
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If possible, please write in german (it is easier for  
me), but I will answer in english, too.