Network Performance in an Urban Context

Martin Margreiter: Leveraging Wireless Technology for Travel Time Estimation and Traffic Management on Freeways

Host – Symposium Sponsor

International Partners

National Supporters

HELLENIC REPUBLIC
MINISTRY OF INFRASTRUCTURE AND TRANSPORT

HELLENIC REPUBLIC
Ministry of Digital Governance

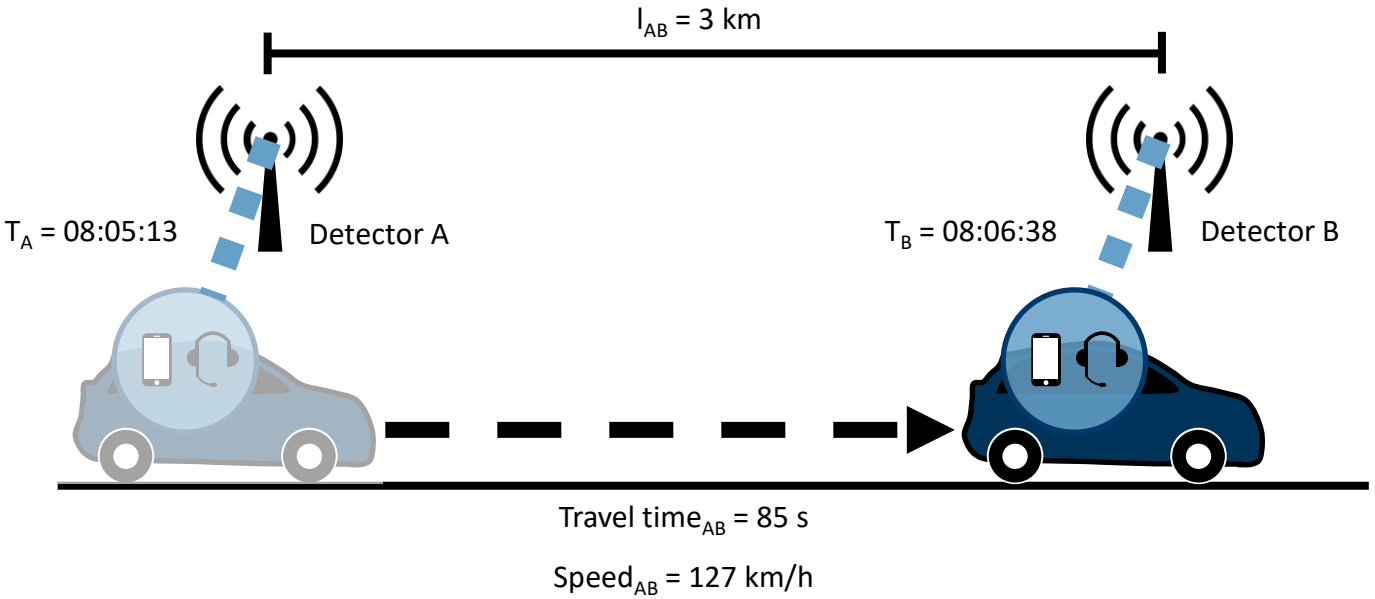
Leveraging Wireless Technology for Travel Time Estimation and Traffic Management on Freeways

Martin Margreiter

- Department Head Mobility Innovation Campus, IABG, Germany
- German Delegate at PIARC TC 2.4 “Road Network Operation -ITS”
- Partner at MobilityPartners, Germany www.mobility-partners.com
- Lecturer and PhD supervisor at TUM and TUM Asia

Wireless Detection Principle

- Bluetooth or WiFi detectors alongside the road segment.
- Detection of wireless devices on board of vehicles.
- Detection range of several 100 meters.



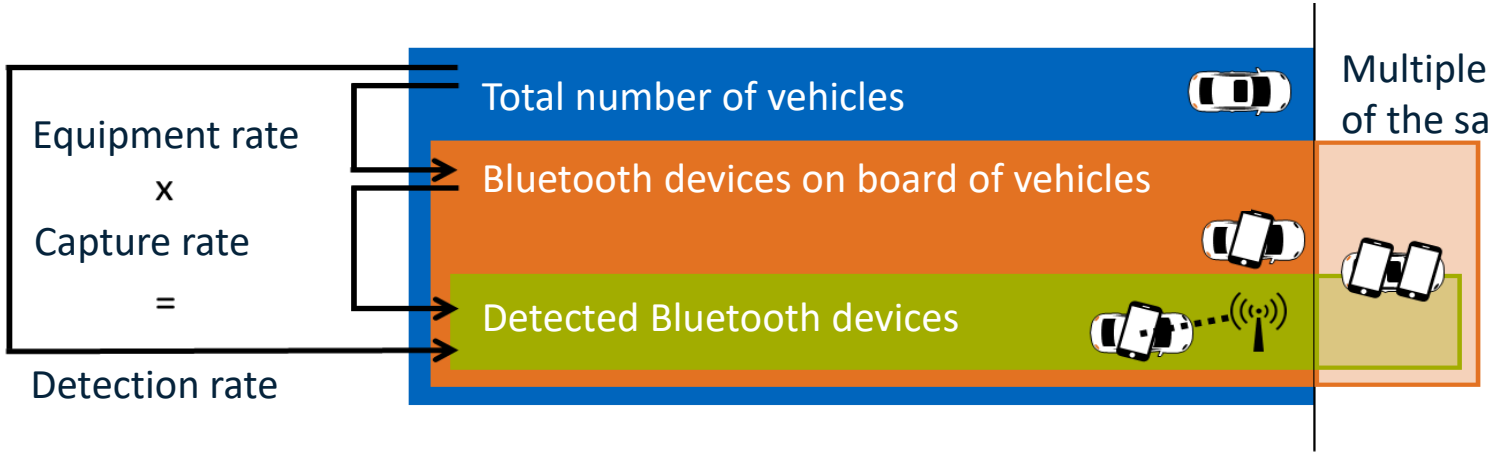
Date	Unix time	MAC address	Detector
26.04.2010	1272297470	00:02:60:0D:AA:EB	A
26.04.2010	1272301060	00:05:99:65:40:9A	A
26.04.2010	1272301360	00:07:00:E8:1A:0F	A
26.04.2010	1272301850	00:06:30:D4:BA:95	A
26.04.2010	1272301860	00:08:20:51:B5:6B	A
26.04.2010	1272301910	00:01:10:FC:B0:EA	A
		12:9F:44:C6	A
		01:57:52:E7	A
		10:FC:B0:EA	B
		60:0D:AA:EB	B
		12:9F:44:C6	B
		01:57:52:E7	B
		00:E8:1A:0F	B
		30:D4:BA:95	B
		99:65:40:9A	B
		20:51:B5:6B	B

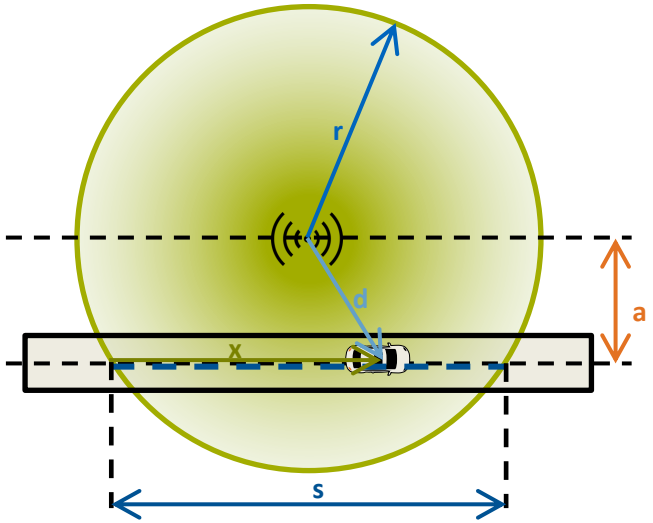
MAC address	Travel time A->B	speed
00:01:10:FC:B0:EA	100 s	180 km/h
00:02:60:0D:AA:EB	4550 s	4 km/h
00:03:12:9F:44:C6	120 s	150 km/h
00:04:01:57:52:E7	110 s	164 km/h
00:05:00:E8:1A:0F	990 s	18 km/h
00:06:30:D4:BA:95	210 s	86 km/h
00:07:99:65:40:9A	710 s	25 km/h
00:08:20:51:B5:6B	220 s	82 km/h

Example: Bluetooth Detections in Bavaria

- Large Bluetooth detection testbed in Bavaria, Germany.
- Joint testbed of TUM with the Free State of Bavaria, Germany.
- Covering several 100 km in the Southern German freeway network.
- Almost 1 billion individual detections analyzed since 2010.
- Integration of Bluetooth detection in traffic management:
  - Determination of travel times and OD-matrices for the whole freeway network.
  - Automatic incident detection and large-scale re-routing advices to drivers.

Detection Rate Definition



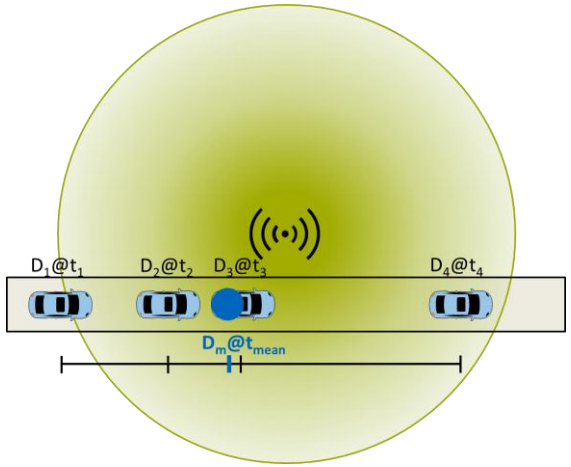


$$v_{max} = \frac{2 \cdot \sqrt{(r^2 - a^2)}}{t_{req}} \cdot 3.6 \frac{km/h}{m/s}$$

$$d = \begin{cases} \sqrt{a^2 + \left({}^{s}/_{2} - x\right)^2} & for\ x \leq {}^{s}/_{2} \\ \sqrt{a^2 + \left(x - {}^{s}/_{2}\right)^2} & else \end{cases}$$

$$d = \begin{cases} \sqrt{a^2 + \left(\sqrt{(r^2 - a^2)} - x\right)^2} & for\ x \leq \sqrt{(r^2 - a^2)} \\ \sqrt{a^2 + \left(x - \sqrt{(r^2 - a^2)}\right)^2} & else \end{cases}$$

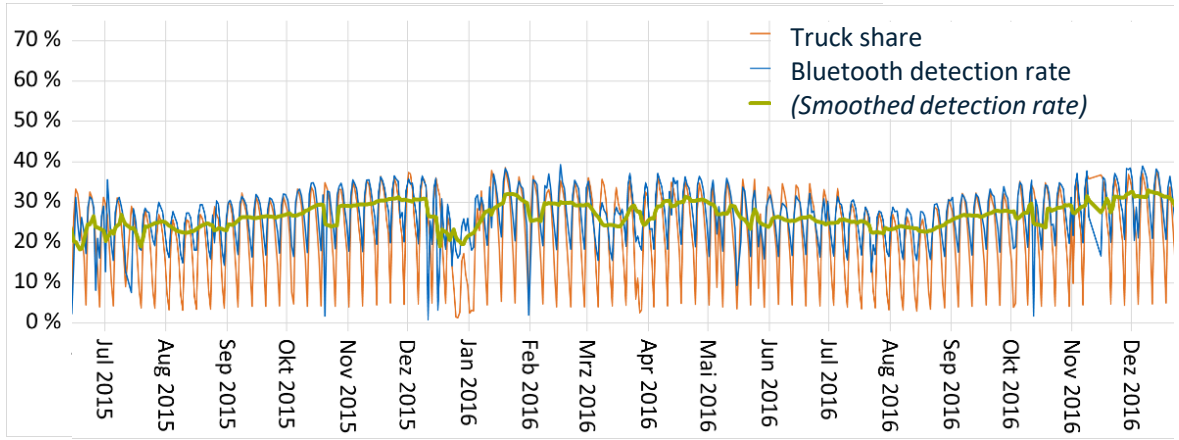
Detection Procedure: Mean-Mean



Evaluation of Detection Rates

- Continuous detection rate of 25.6 % over several years.
  - Ranging between 11.7 % and 35.3 % depending on:
    - Truck share.
    - Daily traffic pattern.
    - Sensor location.
    - Sensor installation height.

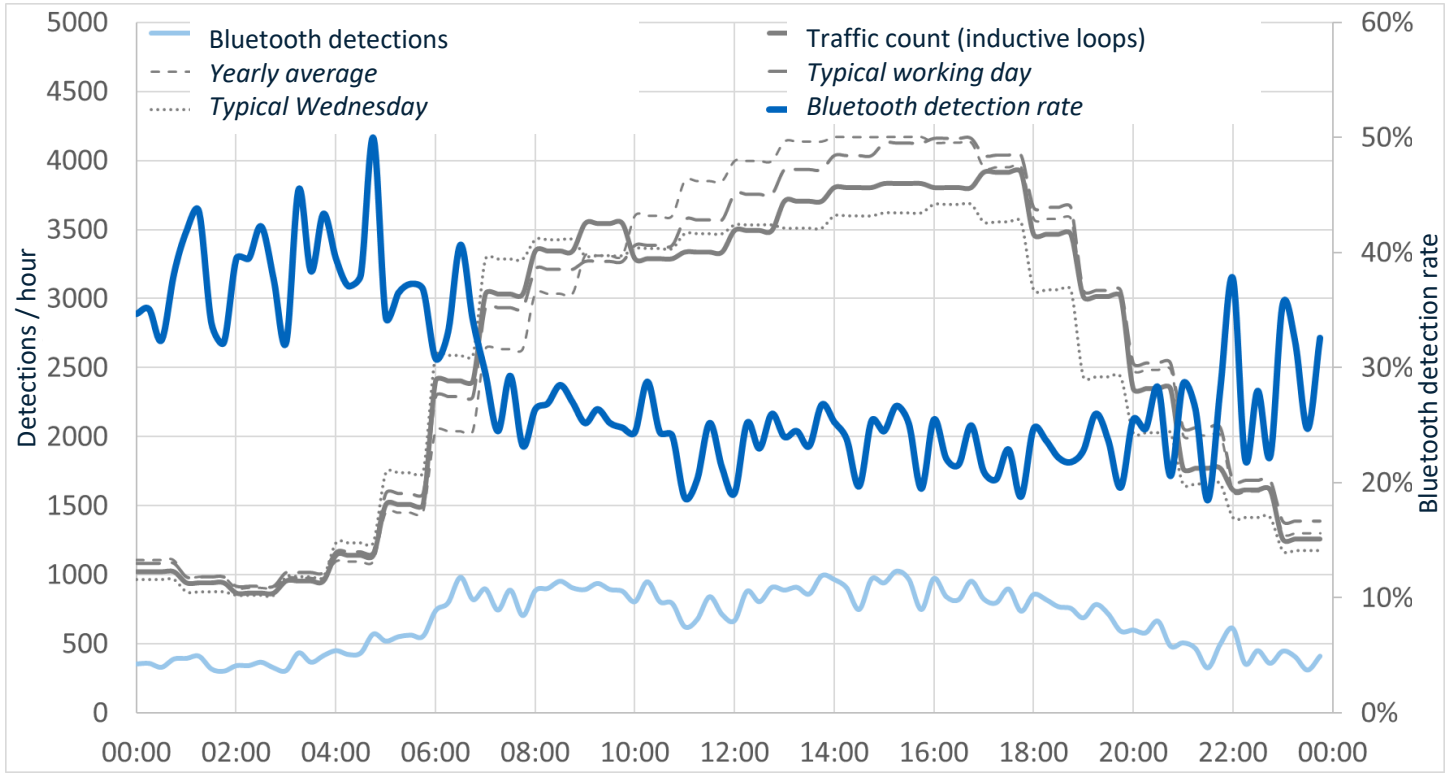
- International comparison (examples):
  - US: 0.7 – 46 %
  - China: 5.9 – 7.4 %
  - Australia: 5 – 40 %
  - Netherlands: 25 – 70 %
  - Thailand: 20 – 90 %
  - Denmark: 4.5 – 20 %
  - Croatia: 10 – 12.2 %



- Strong variation between working days and weekend.
- Impact of days with truck driving ban (e.g bank holidays).

Detection Rate: Influence of the Time of Day

- Strong variation depending on the time of the day.



Detection Rate: Influence of Trucks

- Truck share at the testbed:
  - Slight increase over the years.
  - Depending on the road segment in the freeway network ranging between 7.5 % and 25 %.
  - Average throughout the network: 18.1 %.
- Trucks show a higher equipment rate with Bluetooth devices than passenger cars.
  - Significant impact on traffic state detection (truck speed limit in Germany: 80 km/h).
  - Therefore: Truck equipment rate must be included in the traffic state detection.
  - No impact at traffic states with low average speeds (<80 km/h) and in congested situations.
- Determining the Bluetooth equipment rate:
  - Assumption of a similar equipment rate on all segments of the freeway network.
  - Determined Bluetooth equipment rate of passenger cars: 12 – 17 %.
  - Determined Bluetooth equipment rate of trucks: 65 – 70 %.

Conclusions

- Constant Bluetooth detection rate of ~25 %:
  - Proven sufficient for traffic state determination.
  - Proven sufficient for OD-matrix calculation.
  - Proven sufficient for automatic incident detection (AID).
  - Truck share has to be taken into account due to higher equipment rate.

- WiFi detection has the same detection principle:
  - Can complement the data collection and provide an even higher detection rate.
  - Detection of multiple devices on board (with WiFi and Bluetooth) is crucial.

References

- Margreiter, Martin (2020). The Impact of Trucks on the Bluetooth Equipment Rate on Freeways. 23rd EURO Working Group on Transportation Meeting.
- Margreiter, Martin; Busch, Fritz; Carstensen, Christian (2019). The Evolution of Bluetooth Detection Rates. Transportation Research Board, 2019.
- Margreiter, Martin; Busch, Fritz (2018). Bluetooth Detection as a Low Cost Data Source for Freeway Management. PIARC International Seminar on Integrated Road Transport and Mobility, Cape Town, South Africa.
- Margreiter, Martin (2018). Bluetooth Technology for Motorway Management and Motorway Technology. PIARC International Seminar on Integrated Road Transport and Mobility, Cape Town, South Africa.
- Margreiter, Martin (2016). Fast and Reliable Determination of the Traffic State using Bluetooth Detection on German Freeways. World Conference on Transport Research, Shanghai China.
- Margreiter, Martin (2016). Automatic Incident Detection Based on Bluetooth Detection in Northern Bavaria. Transportation Research Procedia.
- Margreiter, Martin; Spangler, Matthias; Zeh, Tobias; Carstensen, Christian (2015). Bluetooth-Measured Travel Times for Dynamic Re-Routing. 3rd Annual International Conference on ACE 2015, Singapore.

THANK YOU!

Martin Margreiter, IABG, Germany
margreiter@iabg.de

Host – Symposium Sponsor

International Partners

National Supporters

HELLENIC REPUBLIC
MINISTRY OF INFRASTRUCTURE
AND TRANSPORT

HELLENIC REPUBLIC
Ministry of Digital Governance