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ICT systems for intelligent wireless dynamic EV charging
Overview

- Introduction to wireless charging
- FABRIC -- Feasibility analysis and development of on-road charging solutions for future electric vehicles
- Dynamic wireless charging systems ICT
- Intelligent charging
- Conclusion
Introduction to wireless charging

• Allows EV charging while travelling (dynamic) or during short stops ideal for urban environment (stationary)

- Increased range
- Smaller batteries
- Increased mobility
- No visual pollution

- Reduced range anxiety
- Cheaper EVs
- More comfort
- Safer

• Drivers do not have to deal with dirty and potentially dangerous cables (rain, cable vandalism, cable wear, etc) + Easier charging process
FABRIC

- User requirements
- Technical feasibility
- Standardization/Interoperability

Dynamic wireless charging of FEV

Relationship with other projects
Innovation
Collaboration

Jan 2014

Budget: 9 M€
Duration: 48 months
Coordinator: Angelos Amditis, ICCS
Website: www.fabric-project.eu

Funding: 6.5 M€
Start: 1 January 2014
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Jan 2018

Coordinator: Angelos Amditis, ICCS
Dynamic wireless charging systems ICT 1/2

- Increased on-board to off board system connectivity is enabled through a diverse set of communication technologies. (DSRC, Mobile comms 4G-5G)
Dynamic wireless charging systems ICT 2/2

• ICT connectivity between off board enables functions such as
  ▪ Authorization, Billing, Alignment assistance, **Intelligent charging**
Intelligent charging: Introduction

• Motivation
  ▪ Ensure charging at minimum cost
  ▪ Ensure reliable grid operation

• Manner
  ▪ EVS consult the intelligent charging management module and modify charging power levels accordingly

• Intelligent charging ICT must
  ▪ Host interfaces to both Energy Retailers and DSO (Distribution System Operations) in order to receive associated constraints to the aforementioned objectives
  ▪ Employ a global charging strategy taking constraints into consideration!
Intelligent charging: Architecture

- Energy retailer
- DSO

Optimal charging pattern (Active power Vs Time)
Charging constraints (Maximum active power)

Charging infrastructure
Intelligent charging: Dynamic Wireless Power Transfer (DWPT)

• Dynamic wireless charging perspective
  ▪ No formal charging duration—Vehicles may choose to quit the charging lane randomly
  ▪ Number of vehicles charging concurrently varies heavily
  ▪ Charging over a single pad lasts for some ms!

• Intelligent charging management ICT must be reviewed, taking the above into consideration. The following feasibility example is representative
Intelligent charging: DWPT Feasibility example

- Vehicle moves at $U=100\text{km/h}$
- The length of each charging coil is $L=1.5$
- The spacing between each coil is $DL=0.2\text{ms}$
- The maximum time for which the intelligent charging problem remains constant is $T=\min \left(\frac{L}{U}, \frac{DL}{U}\right)=7.2\text{ms}$
Intelligent charging: DWPT Feasibility example

• Therefore only 7.2ms are available to solve the intelligent charging problem.

• According to the flow proposed by ISO/IEC 15118, OCPP the overall latency of defining the intelligent charging power level is

\[ T_{ocpp} = 2 \times T_{dsrch} + T_{http} + T_{processing} \]

For \( T_{dsrch} = 3.5\text{ms} \), \( T_{http} = 1\text{ms} \),

\[ T_{ocpp} > 8\text{ms} > 7.2\text{ms} \]
Intelligent charging: DWPT Feasibility example

- Typical intelligent charging protocols introduce lattencies which are tolerable in the case of static or stationary charging but not dynamic.

- Adopt adaptive control techniques for intelligent charging:
  - Set charging power rates at the EV level immediately without consulting the infrastructure and let the infrastructure make corrective actions if required!
  - Example: Additive Increase Multiplicative Decrease (AIMD)
Intelligent charging: Dynamic wireless power transfer

• In Additive Increase Multiplicative Decrease (AIMD)
  ▪ EV charging controllers increase their charging rates linearly without consulting the infrastructure.
  ▪ The infrastructure interferes correctly only if a reduction in charging rates is required.
Conclusion

• Dynamic wireless charging requires special handling w.r.t to intelligent charging (Smart charging)
• Associated standardisation must revise communication protocols in order to address novel requirements
• Adaptive control algorithms are required to address the requirements of the problem.
Thank you!
Questions?

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