Exploring IoT Co-Dependencies in Electro-Mobility

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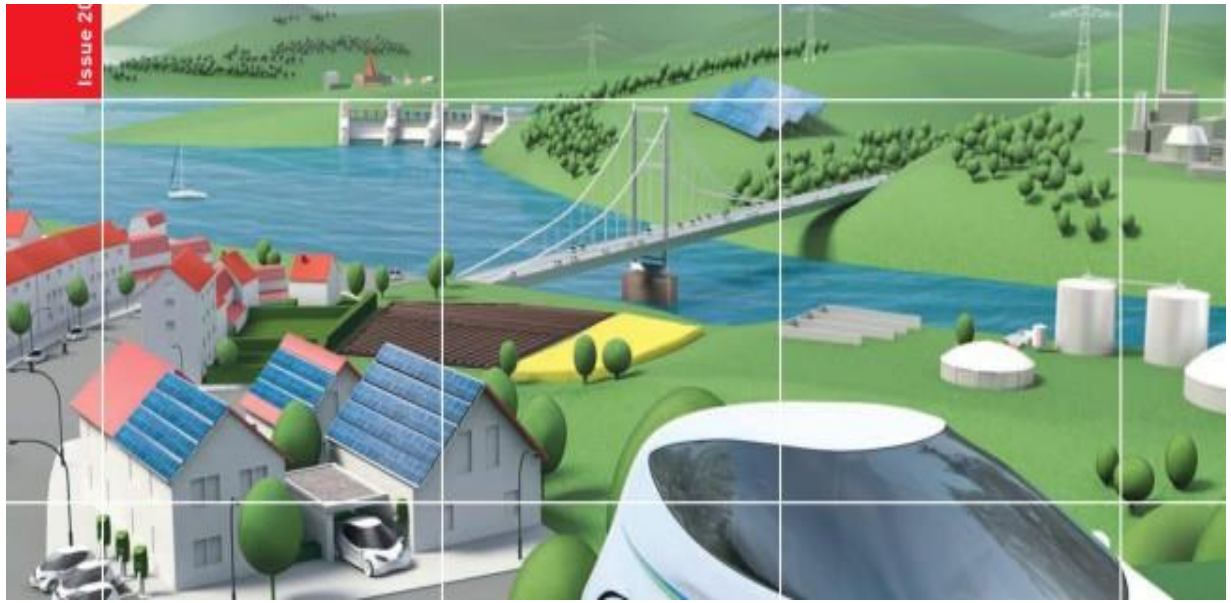
Interdependent Cyber-Physical Systems

- Water – Food – Energy
- Health – Telecommunication – Food
- Transportation – Food – Health
- Transportation – Civic Infrastructure – Power Grid

http://www.umt.edu/bridges/stories/know-nexus.php

Electro-Mobility



http://v2city-expertgroup.eu/2016/02/16/electromobility-in-germany-vision-2020-and-beyond/

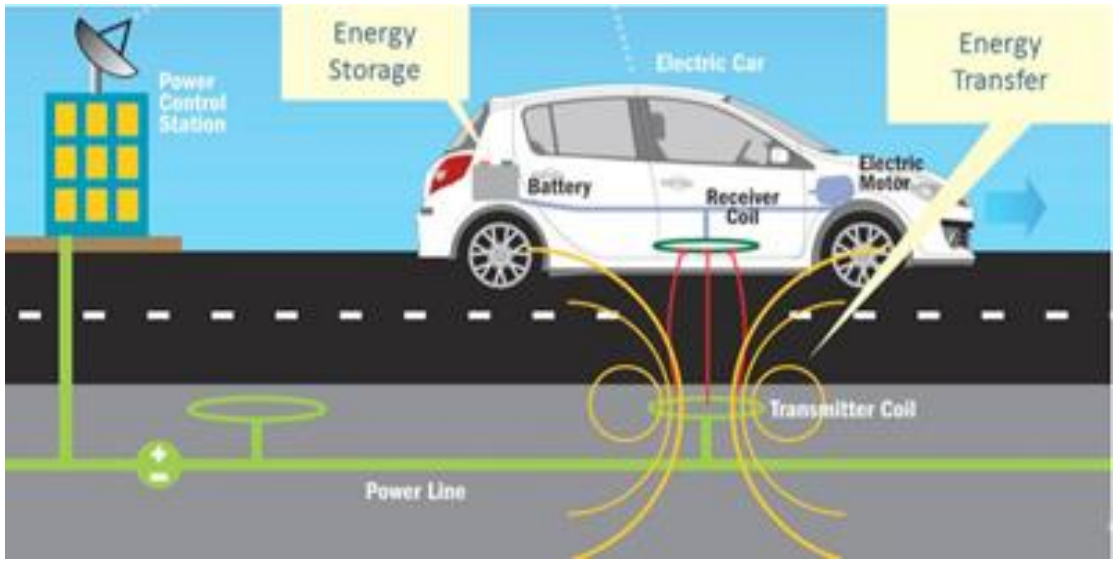


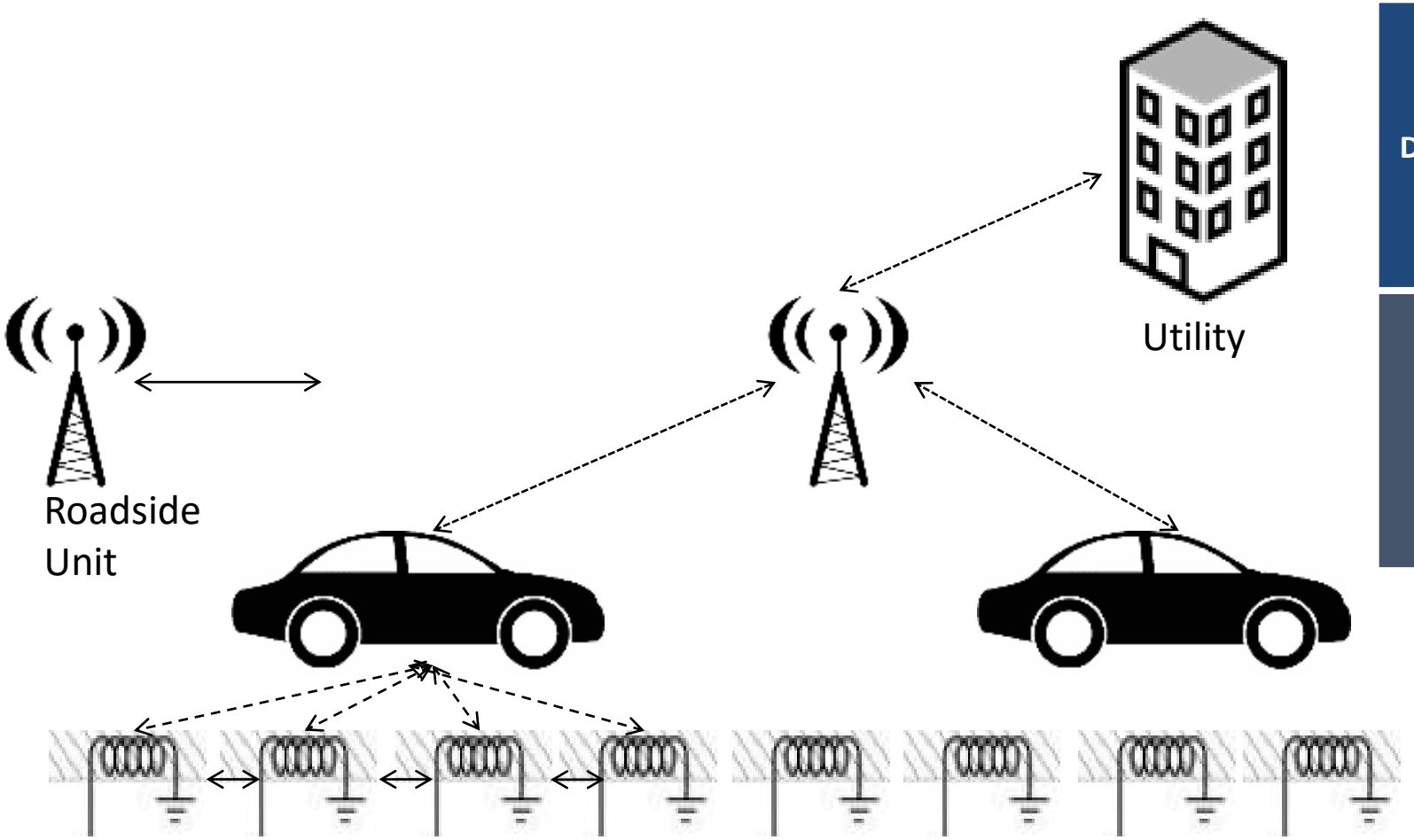
Image: http://gcep.stanford.edu/images/news/wireless_car_charging_400px.jpg

Interdependency in Electro-Mobility using Dynamic Wireless Charging

- Electric Vehicles (EV)
- Road Infrastructure
- Telecommunication
- Energy Utility Provider

Photos: courtesy of Oak

EV CPS Interdependent Eco-System



Dynamic Charging	Battery Monitoring	N/A
Static Charging	Selling Energy to Grid	Pre-computation

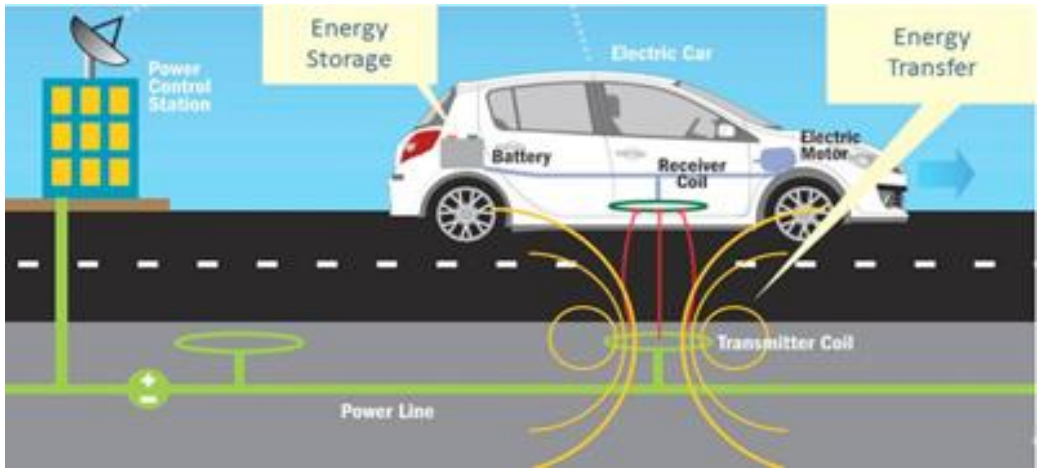
Different interdependencies and context require different level of security and privacy

Challenges of Dynamic Wireless Charging

- Challenge: Impact on EV speed
  - if we have 2 m long coils of 20 KW, one needs to go slowly at 36 km/h
  - If one goes at 108km/h, one has only 200ms charging time
- Challenge: Impact on Power Grid
  - Simulation study by FABRIC project:
    - If one considers average 10 EV/km/lane over 1 hour with 500 simulated EVs with max capacity 30 EV/km/lane, then one can achieve 2-8 MW load demand
    - We will need energy storage system if demand fluctuation which will be the case
    - Energy storage systems can minimize demand variability
      - Overall peak load reduction will be less expensive
    - Load shaping and shaving is needed!!!

Challenges for Electric Vehicle Communication

Dynamic Charging	**Battery Monitoring**	**N/A**
Static Charging	**Selling Energy to Grid**	**Pre-computation**



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- Messages exchanged between EV and each charging pad should be **encrypted** and **authenticated – REAL-TIME AUTHENTICATION**
  - Short contact time with each charging pad (~ 25 ms)
  - FADEC solution – still issues with key distribution and management across domains
- Unlinkable pseudonyms **within the same charging section** are **not necessary**, since a charging section is typically several kilometers long.
- Unlinkable pseudonyms **across different charging sections** are needed to preserve the EV's location privacy **– LOCATION PRIVACY**
  - Portunes+ solution for privacy-preserving fast authentication – still issues regarding scale, billing

Challenges for Electric Vehicle Communication

Dynamic Charging	Battery Monitoring	N/A
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- How to prevent someone from unplugging the charging wire from your EV and plug it into theirs? – **PREVENTION OF ELECTRICITY THEFT**
- How does user pay without compromising their location privacy? – **PRIVACY-PRESERVING BILLING**
  - Janus solution for billing under dynamic charging– still issues regarding scale, who drives billing process and which sector does the customer pay to.
- EV's location privacy must be preserved **across different charging stations**. – **LOCATION PRIVACY**

Challenges for Electric Vehicle Communication

Dynamic Charging	**Battery Monitoring**	N/A
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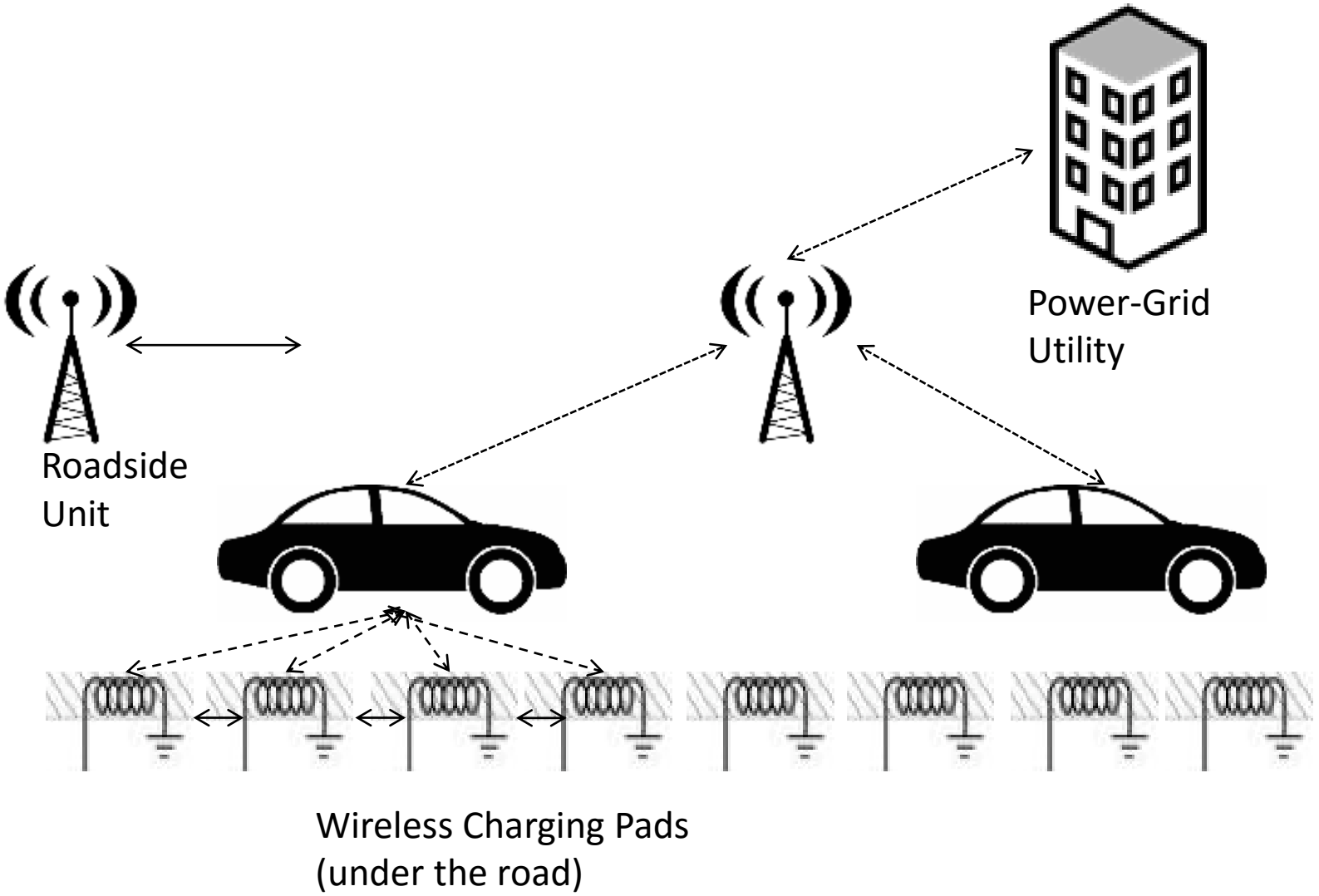
- Sporadic Reports – **PRIVACY-PRESERVING PROTOCOLS AMONG CPS DOMAINS**
  - EV sends only a few reports at different times of the day
  - The utility should not be able to infer that different reports are sent by the same EV
- Stream Reports – **TRUSTWORTHY AND CONTEXT-AWARE PROTOCOLS AMONG CPS DOMAINS**
  - EV sends lots of reports within a short period
  - The utility must be able to infer that these reports come from the same EV in order to build the real-time charging profile

Challenges for IoT in Electro-Mobility Environments



- **We do not change cars, power-grid meters, roads at the same pace as our mobile phones**
- Sustainability and IoT Upgrades
- Integration of different IoT infrastructures and platforms
- Key Management across different domains/sectors
- Privacy and Security Leakage due to different protection schemes and policies

Conclusion

- Electro-Mobility will require long term vision towards 2050
  - Car industry already talks about 2050 vision
- Interoperability and collaboration among car companies, smart grid, cities, IT companies, telecommunication industrial domains must happen
  - The collaboration and coordination has to happen at many levels
    - Protocols
    - Sensing devices
    - Security, Privacy, Performance Policies
    - Analytics
- Standards across different domains
- Many questions remain:
  - Who will be in charge?
  - How will companies develop devices, platforms, protocols, that integrate easily and expand, replace aging cyber-infrastructures?
  - How will billing and security frameworks look like?