A LOAD BALANCING CONTROL ALGORITHM FOR EV STATIC AND DYNAMIC WIRELESS CHARGING

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Electromobility vision and ojectives

Large-scale adoption of pure **Electric Vehicles (EVs)** in future transportation systems through **Advanced on-road charging solutions** to improve:

- driving range and battery lifetime; energy efficiency and price of the Full Electric Vehicles (FEV), given the need for a smaller battery.

The future of EV charging: Wireless

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

Increased range → Reduced range anxiety

Smaller batteries → Cheaper EVs

Increased mobility → More comfort

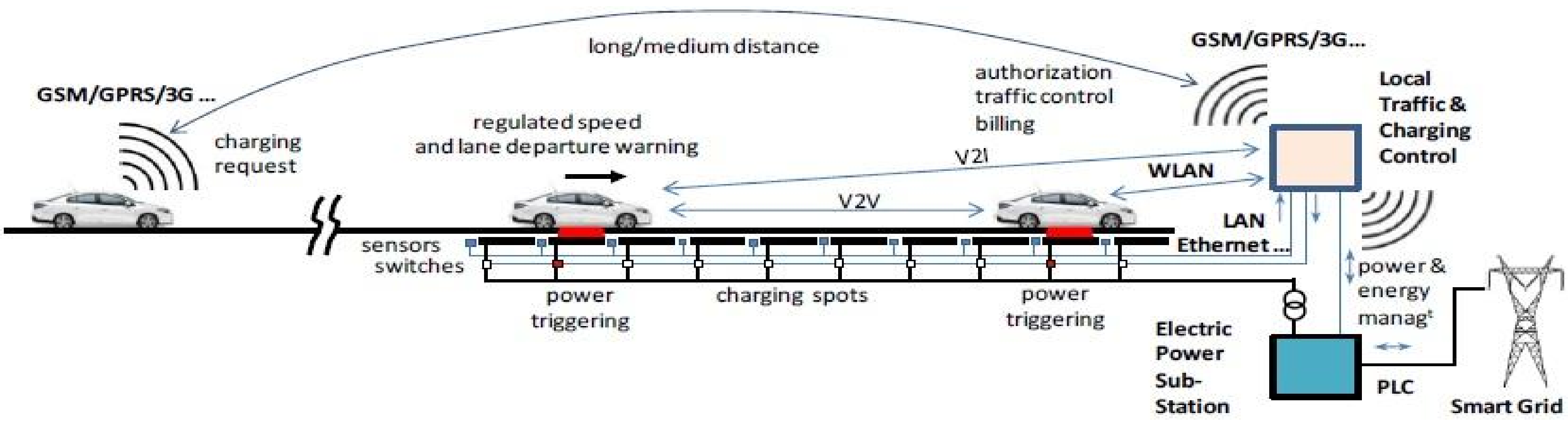
No visual pollution → Safer

Driver benefits: 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); the charging process is easier

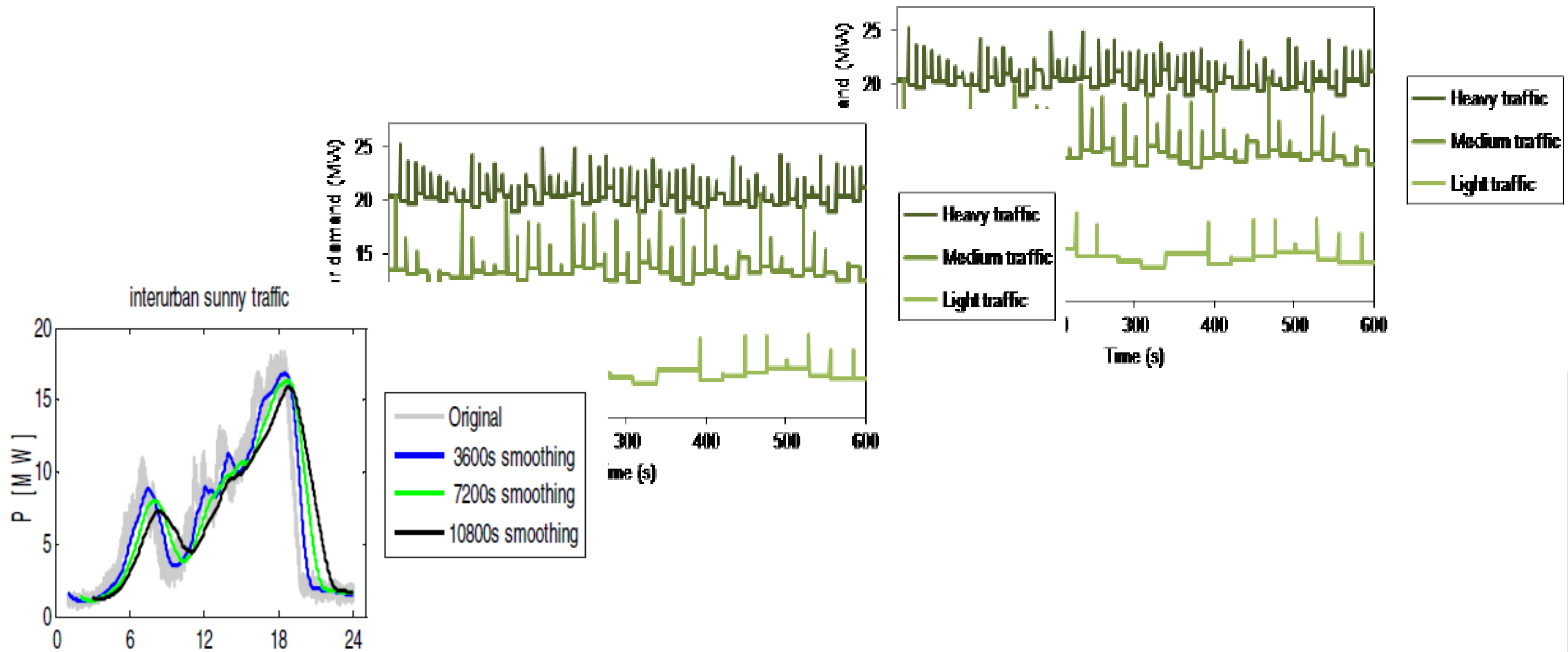
Dynamic wireless charging

- Charging process
  - Vehicle authorization
  - Charging profile negotiation
  - Power transfer while vehicle over the pads
  - Billing, payment, etc…



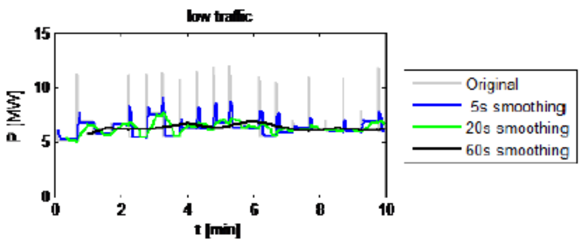
SID EFFECTS: GRID IMPACT?

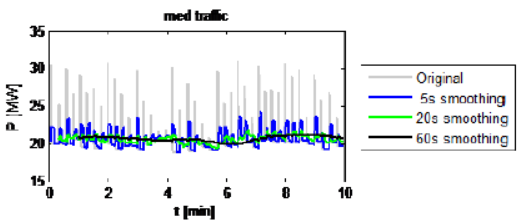
- How does this procedure affect the power grid? (What kind of power demand patterns are generated)



ENERGY STORAGE SYSTEM SOLUTION

- In the urban case most fluctuations have been removed with smoothing window of 5s i.e a storage system rated 11.4MW @ 8.2kWh
- In the interurban case smoothing requirements are lower. In order to smooth the demand a 60s window is required 2MW @ 8kWh
- Due to high charge and discharge power, systems must be placed near to the power transfer zones



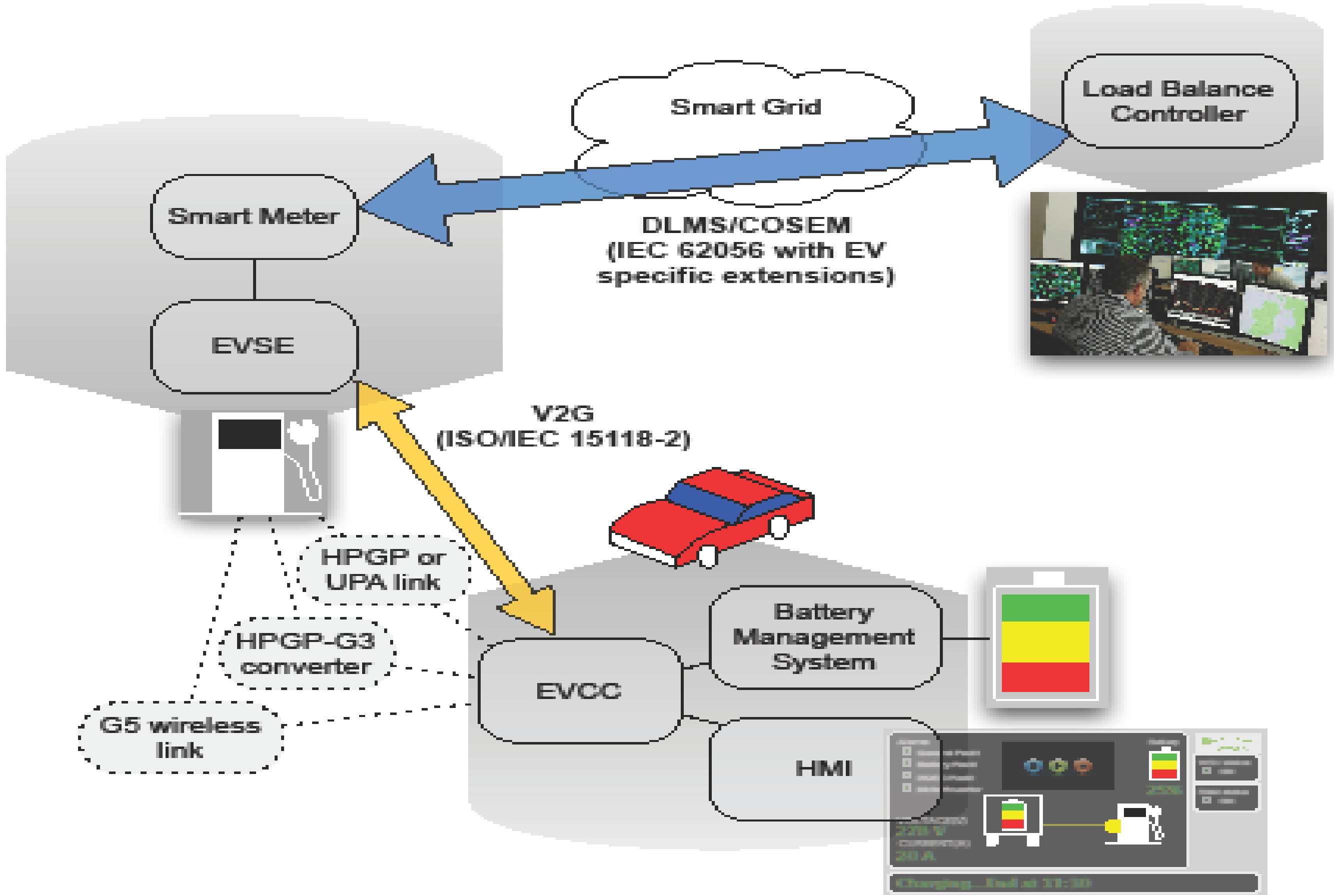


OR /AND ICT: LOAD BALANCING

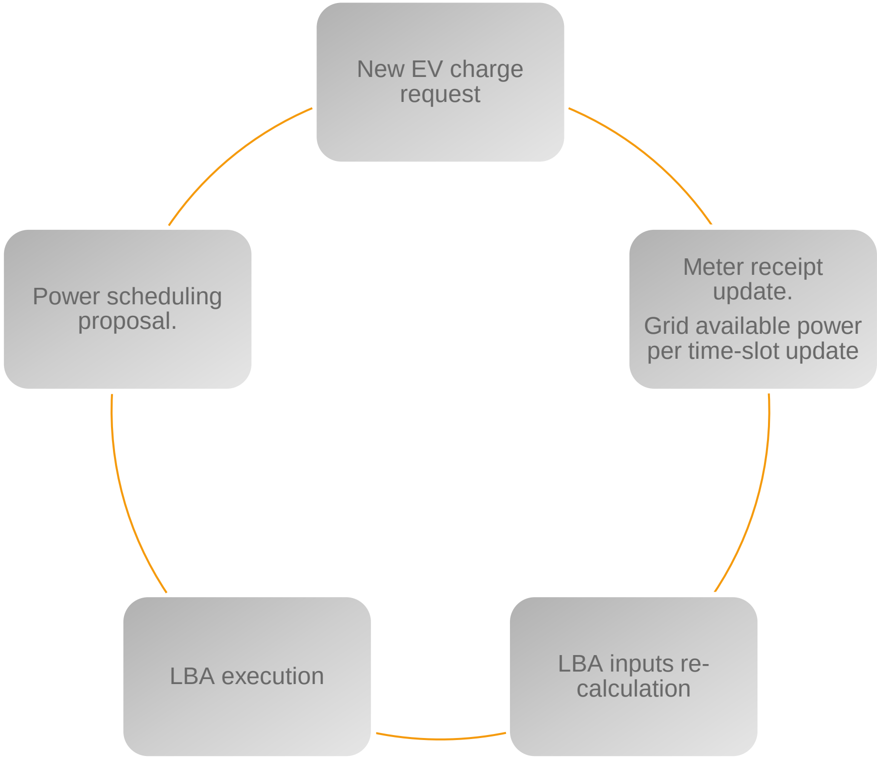
Removing demand fluctuations

- Minimization of frequency variations due to demand supply mismatch (ensure grid stability)
- Minimization of losses due to load fluctuations
- Minimization of costs from over-dimensioning the grid
- …
- Providing ancillary services
    - Vehicles request for energy resources. Power allocation flexibility can be controlled to offer additional services

INDICATIVE ARCHITECTURE



FUNCTIONAL OVERVIEW



LOAD BALANCING PROBLEM

- Find the optimal charging schedule given EV constrains/preferences

Vehicle	Priority	Voltage (V)	Max P (W)	Eamount (Wh)	Time slots
1	1	230	920	1000	5
2	2	230	690	750	6
3	3	230	460	500	5
4	4	230	230	250	2

…and grid constraints….

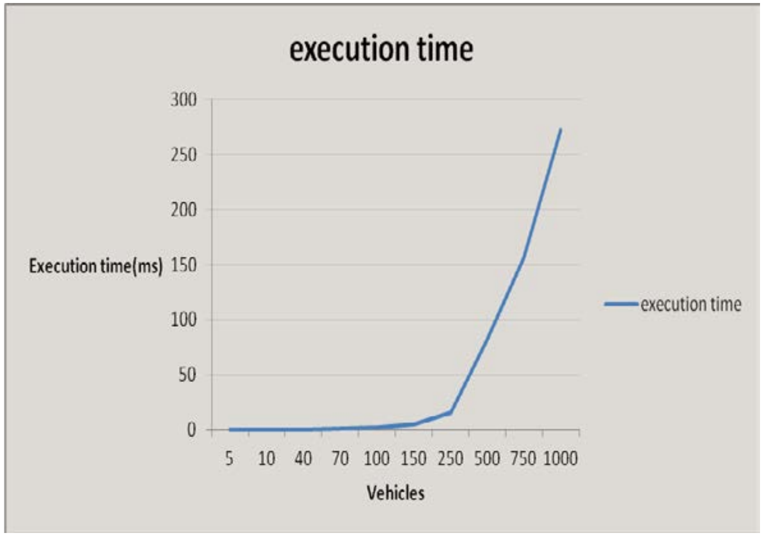
Slots	1	2	3	4	5	6
P_{grid} (W)	200	400	600	800	1000	1200

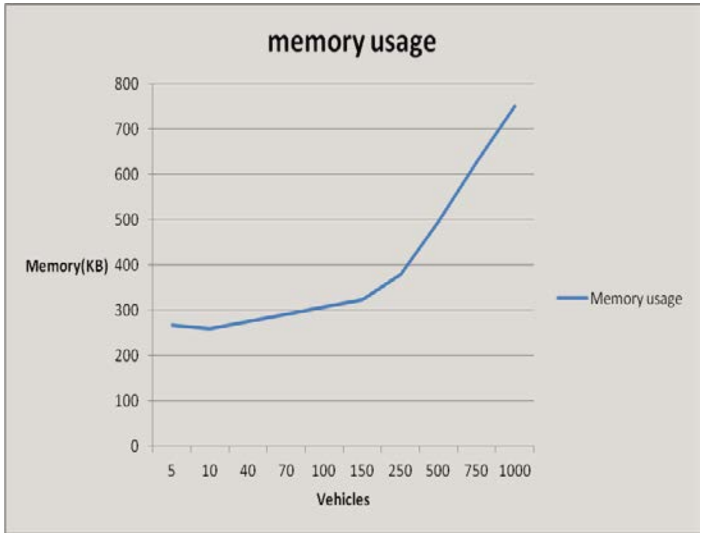
PROBLEM SOLVING PROCEDURE

- Decompose the overall problem to minor ones
  - Create a list of descending priority EVS
  - Allocate power to starting from the highest priority EV from "latest" to earlier timeslots
  - Re iterate over the list and swap power from one timeslot to another to optimize each charging schedule according to preferences.(Cheaper, faster departure, etc…)

Performance And Scalability

- LBA performance indicators.
  - Execution time vs EVs taken as input on a LBA iteration
  - Memory footprint(LBA only)





Overall characteristics of the LBA

- Local area charging controller optimized resource allocation.
  - Load shifting.
  - FEV charging profile generation, according to requested departure time and energy amount
- Interactive charging control
  - Support for user/grid initiated power delivery re-negotiation
- Power delivery prioritization
  - Guaranteed/Normal power delivery.

Future Work

- Consider and compare various approaches w.r.t
  - Computational complexity
  - Scalability
  - Performance
  - Communications overhead
- Focus on hard real time constraints (Dynamic wireless charging)
- Assess requirements for an overall holistic approach to smart charging across all types (Static, Stationary, Dynamic)
- Consider the overall charging framework with focus on EV oriented optimization strategies

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