Intelligent Cooperative Sensing
for Improved traffic efficiency

IoT CoAP Plugtests™ & Workshop
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• Cooperative V2X communications and cellular networks are enabling closed loop interaction between vehicles/drivers and the transportation infrastructure.
• Enabling technologies are entering their mature phase, e.g., traffic flow sensors and IEEE 802.11p
• There is still the need of a complete integrated solution that can take the most benefits from a real-time analysis of the data gathered and appropriate reaction on the transportation system
• This requires decentralized aggregation and decision for robust and timely decisions to be taken
• An additional and significant improvement can be brought by pro-active decision making processes, with the integration of predictive models running in real-time alongside the reaction schemes
Intelligent Transport Systems

- **Challenges:**
  - Permanent congestion on highways and urban centres
  - Energy waste
  - CO₂ emissions
  - Impact on public health and accidents rate

- **Forecast growth in transport:**
  - Congestion costs will increase by about 50% by 2050[^1]

- **Main objectives:**
  - Transport efficiency
    - Less congestion
  - More safety
    - Less accidents
  - Energetically sustainability
    - Less CO₂ emissions

- **Intelligent Transportation Systems (ITS) should play the role in contributing to tangible results quickly and efficiently.**

[^1]: Transport White Paper (March 2011)
The goals

• ICSI aims:
  – To address simultaneously the challenges raised by the ITS
  – To give a qualitative leap towards the future mobility

• ICSI platform goals are:
  – merging and integration of heterogeneous data sources into a common system
  – provisioning of a set of advanced tools for control, monitoring, simulation and prediction of traffic
The vision (1/2)

• Today ITSs are often composed by vertical and closed sub-systems which do not provide interfaces for direct access to third parties.
  – Aggregation and integration of data provided by different sub-systems operating in the same area is very difficult in practice
  – The situation is bound to become worse in the future as the ICT infrastructure in transportation become bigger and more complex

• In ICSI, the interaction between heterogeneous data sources is achieved:
  – providing a common layer for data distribution
  – distributing the intelligence for decision making from humans in control centers to machines composing the ICT infrastructure
The M2M interaction between sensors (e.g., traffic flow) and actuators (e.g., variable message signs) will be enabled with local scope.

- Scalability
- Reliability
- Bounded reaction times
- Cooperative sensing
**Central Sub-system**
- stores and elaborates data from the peripheral sub-systems and provides feedbacks/ actions

**Road-side Sub-system**
- also called Road-Side Unit (RSU)
- is positioned along the road for collecting measurements through sensors, actuating feedbacks and acting as a gateway for vehicle communications
- variable message signs, EV charging spots, etc.

**Vehicle Sub-system**
- also called On-Board Unit (OBU)
- resides into the car and can be equipped with sensors and wireless networking equipment for V2X communications.

**Personal Sub-system**
- is embedded in portable devices used by pedestrians and citizens
- is involved with the collection of news, travel information and other kinds of information
- Smartphones, tablets, e-book readers, etc.
Overlay networks

- ○ Actual node in the physical network
- ■ Actual overlay network daemon
- □ Overlay network node
- Physical network link
- Physical link used by the overlay network
- Virtual overlay network link
Peer-2-Peer overlays
The system relies on local distributed storage and intelligence which operates on a limited geographical scale where data are distributed and processed in real-time without the need to contact the central sub-system.
ICSI uses the concept of “gateway” (GW) to indicate a logical entity that operates on a local scope.

GW offers capabilities similar to those provided by the CS:
- data storage
- event processing
- alarms
- etc.

GW handles data for a limited number of components in an area.

RS can act as a GW.

- No Aggregation
- ~10 millis
Network architecture

• Each GW is logically connected to:
  – GWs in the same local area, which handle data relevant to its served sensors and actuators.
  • Service
  • Context
  • Resource constraints

√ Low aggregation
√ ~100 millis
• Each GW is logically connected to:
  – GWs outside its local area, which might still need to receive data or provide commands, for instance:
    • congestion on a main road segment might have cascade effects on very large areas
    • drivers far away might benefit from having an early warning by being redirected along alternative paths.
• Each GW is logically connected to:
  – CS in order to provide integrated and aggregated data for:
    • long-term optimizations
    • statistical uses

✓ High aggregation
✓ ~100 secs
• GW implements dynamic and adaptive algorithms able to provide real-time decisions based on the infrastructure and traffic situation (context/resource-awareness):
  – Cooperative Learning Unit (CLU)
• The GW is in charge of:
  – Taking decisions autonomously in response to traffic conditions (context, resource constraints)
  – Integrating information from the WSN and GWs
  – Identifying of abnormal traffic situations
  – Suggesting contingency and actions plans to improve the traffic flow and travel management strategies
    • The GWs will be updated with new traffic models and contingency plans by the Traffic Manager Center (TMC) placed into the CS
    • A Decision Support System in the CS will update and improve traffic models and contingency plans on the base of information reported by the GWs (results of previously actions taken)
Nowadays:

- Many vehicles equip an On-Board Unit
- Some Road-Side Units are already deployed on highways and main roads (VMSs, flow sensors, speed traps, semaphores, etc.)
- Smartphone, tablets, e-books and others personal devices are commonly used by people

Available devices lack of network architecture and service platform
• Protocols
  – IEEE 802.11p
    • Multi-Channel
    • Real-Time MAC
    • Fail-safe (replication)
  – IEEE 1609
  – IEEE 802.15.4
  – IETF 6LoWPAN
  – IETF CoAP

• Architectures
  – ETSI ITS
  – ETSI M2M
  – Etc.
In ICSI:
- Local cloud is connected with a GW
- Local areas are defined dynamically on the base of the running service, the current context and the resource constraints
- Global area enables inter-area communications and connects CS and GWs

ICSI offers a set of intelligent services on top of main ITS and M2M architectures

Intelligent services support intelligent application for Intelligent Transport Systems!

Awareness:
- Service
- Context
- Resource constraints
Context and Resource Awareness

Global Area

Local area

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ICSI over ETSI ITS (1/4)
ICSI over ETSI ITS (3/4)
Model-View-Presenter (MVP)

1. **SEPARATION**
   - The business logic is held by the Presenter

2. **DECOUPLING**
   - Presenter mediates between the View and the Model

3. **TESTABILITY**
   - Passive View exposes a single interface
Thank you for your attention!