Future Traffic Management Concepts and Challenges

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1. WHY TRAFFIC MANAGEMENT (TM)?

- Motorised road vehicle: A highly influential invention ➠ Vehicular traffic
- Vehicles share the road infrastructure among them, as well as with other (vulnerable) users: TM needed
- Few vehicles: Static TM for safety
- Many vehicles: Dynamic TM for efficiency
- Too many vehicles (congestion): Dynamic TM for protection from degradation
Network Fundamental Diagram (NFD)
(Fahri, 2008; Geroliminis & Daganzo, 2008; Helbing 2009)

1. undersaturated; maximise speeds!
2. saturated: maximise capacity!
3. oversaturated: queue management, metering!
4. blocked: call the police or walk home!
Basic elements of an automatic control system

Technology (Sensors, communications, computing, actuators): **Skeleton**

Methodology (Data processing, control strategy): **Intelligence**
Current TM Systems (ITS)

- **Process**: vehicle flow
- **Sensors**: spot sensors
- **Communications**: wired
- **Computing**: central, decentralised, hierarchical
- **Actuators**: road-side
Future TM Systems (C-ITS)

- **Process**: enhanced-capability vehicles
- **Sensors**: vehicle-based
- **Communications**: wireless, V2V, V2I, I2V
- **Computing**: central, massively decentralised, hierarchical
- **Actuators**: in-vehicle

**Implications/Exploitation** for traffic flow efficiency?
2. MAIN CURRENT TRAFFIC MANAGEMENT TOOLS ...

(a) Motorways

- **Ramp Metering**: Few successful installations; Most (even metropolitan) motorways uncontrolled
- **Variable Speed Limits**: Great for safety; No efficiency improvement due to simplistic control strategies

**Current Status**: No capacity flow anywhere/anytime on uncontrolled (or badly controlled) motorways.
(b) Urban Road Networks

- **Traffic Signal Control**: Good progress (but also possible improvements) in non-saturated conditions; No operational system for over-saturated conditions

- **Public Transport Priority**: Very significant advances/implementations

**Current Status**: Reasonable performance but strong degradation when network overloaded.
(c) Driver Information and Route guidance
- Variable Message Signs: Many installations
- On-board navigators: Infancy period

**Current Status**: Virtually no predictive systems; Serious route guidance strategies needed with increasing penetration
(d) Integrated Traffic Control

– Urban/Motorway
– Within Motorway
– Guidance/Control

Current Status: Virtually no integration/synergy
... AND DIFFICULTIES

(a) Organizational
   – Reduced TM awareness
   – Reduced TM funding
   – Research-Practice gap

(b) Operational
   – Sensor density/type/reliability/maintenance
   – Control strategy advances/deployment
   – Closed off-the-shelf systems
   – Difficult field comparison
   – Integrated traffic control
3. EMERGING VACS (Vehicle Automation and Communication Systems)

- **Significant efforts**: Automotive industry, Research community, Government agencies
- Mostly vehicle-centric
- **Implications/Exploitation** for traffic flow efficiency?
- **TRAMAN21**: TRAffic MANagement for the 21st Century (ERC Advanced Investigator Grant)  
  http://www.traman21.tuc.gr/
- **Review** identified 88 different VACS
  - 46 safety related
  - 12 urban traffic
  - 30 motorway traffic
4. POTENTIAL CONTRIBUTIONS OF VACS ...

- Traffic safety: Great benefits
- V2V and V2I communication: What to communicate?
- Abundant/new information (e.g. mobile sensors, OD information): How to use it with benefit?
- Increased capacity (e.g. headway control, platooning, lane changing): Under what conditions?
- On-board, in-vehicle actuators (e.g. route guidance, speed limits): Best usage?
- Increased control granularity (e.g. by lane, by destination, flow splitting): Increased opportunities
- Efficient lane assignment
- Improved incident detection and management
... AND RELATED CHALLENGES

- Modified traffic flow characteristics: New/extended traffic flow models
- New/extended control strategies: Exploit the new opportunities
- Very large-scale systems: Design, actors, reliability, vulnerability, security
- Driver involvement: What role? Acceptance?
- Penetration level: Moving target
- Infrastructure investment: Chicken or egg?
- New operators role/generation?
- Long, evolutionary and uncertain process; contradictory development scenarios
- Legal aspects, liability, privacy, standardisation, ...
5. THE WAY FORWARD

- Connect VACS and TM communities (no need to re-discover the wheel)
- VACS by function: Potential TM applications?
- TM by tool: Potentially useful VACS functions?
- Co-evolution
- TM continues to be vital while VACS are emerging