Systems Integration

Case Study - Intelligent Transportation Systems

Pere Palà

iTIC `http://itic.cat`

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Source: A significant part is from Mark W. Maier and Eberhardt Rechtin's *The Art of Systems Engineering 3rd Ed*

Introduction

Singularities

- Class of system: humans and their behavior are inextricably part of the system
- Distributed architecture (in logical and physical sense)

Key characteristics

- Lack of single client
- Uncertainty in purposes. Unknown evolution
- Voluntary cooperation in deployment and use

Intelligent Transportation Systems

Outline

- Transportation: guidance, control and information systems
- Use computer and information technology
- Applied at individual vehicle, roadways and networks
- Motivator: improve network flow, improve safety, reduce environmental impact, will give market opportunities
- Could evolve into automated highways

Implementations

- Navigators: map + GPS. Real time guidance
- Commercial vehicle fleets: position monitoring
- Real-time traffic conditions
- Intelligent traffic control methods in metropolitan areas: stoplights, reversible lanes...
- Not achieved yet: interconnection

ITS Concepts

Common Decomposition of ITS

- Advanced Traveler Information Services
- Advanced Traffic Management Systems
- Advanced Vehicle Control Systems
- Commercial Vehicle Operations
- Advanced Public Transport

Advanced Traveler Information Services

- Provision of accurate, real-time information on transportation options and conditions
- Computer-assisted route planning. Coupled with traffic prediction and multimode transport
- Computer-assisted route guidance. Coupled with traffic prediction
- Access to public transportation schedules in distant city
- Broadcast of real-time and predictive traffic conditions
- Emergency situation and location reporting (manual or automated)

Advanced Traffic Management Systems

- Improve capacity and flow
- Integrate:
  - traffic sensors
  - traffic signals
  - real-time monitoring and prediction
  - dissemination of route information
  - pricing on demand
- Long term: coupling ATMS with route selection in individual vehicle
- Wide-area prediction is limited. Wide-area monitoring is common

Advanced Vehicle Control Systems

- Automated braking systems
- Assistance in distance following
- Assistance in lateral lane keeping
- Obstacle warning and avoidance. (Backup sensors, emergency maneuvers)
- Vision enhancement in reduced visibility conditions

Advantages

- Space. Parked car: 16 m^2. At 110 km/h 465 m^2
- Lane capacity: 750 car/h @ 8 km/h. 2000 car/h @ 50 km/h. 1000 car/h @ 110 km/h
- Safety

Commercial Vehicle Operations

- Weigh-in-motion for trucks
- Electronic license/tag/permit checking and record keeping
- Hazardous cargo monitoring
- Position monitoring for fleet management

Advanced Public Transport

- Improvements in public transport
- Real-time monitoring of bus, subway, train
- Waiting-area displays
- Electronic fare paying systems
- Time-sensitive pricing

Sociotechnical Issues

- Humans + behavior
- Human decisions
  - Use or not route planning...
  - Buy or not components of ITS
  - Political decisions on infrastructure

Who is the Client for an Architect

- ITS: a system no one owns
- Distributed decisions by governments and consumers
- If there is a single client, integrity of the system is maintained by architect hired by client
- Architect has to use indirect means to establish and maintain the architecture
- Actual users are different from the sponsors
- Preferences and needs of users vs. preferences and needs of sponsors
- Architect of ITS is similar to urban planner
- Has the ability to say *no*. Saying *yes* does mostly nothing (except if there are funds)

Public or Private?

- First wave: public infrastructure
- Most traveler information systems are private
- Why comply with centralized route guidance? (Benefit of the whole vs. benefit of the individual)
  - *In introducing technological and social change, how you do it is often more important than what you do.*
  - *If social cooperation is required, the way in which a system is implemented and introduced must be an integral part of its architecture*
- Not the same in each country and culture!
  1. Private development and purchase
  2. Private development and purchase. Government standards or guidelines
  3. Private development and purchase. Government mandating
  4. Government-financed development and private purchase
  5. Government-financed development with government mandating

Facts and Perceptions

- How to know if an ITS is successful or not?
- Average speed, accident rate ...
- *Success is in the eye of the beholder*
  - 15 years from now. There are > 4 competing information providers. Great activity, communication, display, algorithms... Traffic is worse than now.
  - 15 years from now. Government mandates and enforcement have made a widely deployed system. Effectiveness higher where stricter enforcement. Traffic is substantially better.
- In socio-technical and collaborative systems, users are very important
- Success may come from something unforeseen (e.g. travel time variance reduction)

Shared Invariants

- Things shared by most users...
- ...that do not change much with time
    - Positioning services (GPS)
    - Map data: network of roads and their positions
    - Encoding of digital traffic messages
    - Mobile communication networks over which traffic information flows

Economics

- Current achievements in ITS $\leftrightarrow$ Profitable business
- Example: Online map services
  - Large user base allows advertising
  - With valuable added information (travel destination)
- It works because the economics works