

Learning from the Impossible

Practical projects in systems engineering

Ian Sommerville
Lancaster University

Why systems engineering?

- In the vast majority of institutions, software engineering is taught in isolation.
- We try to teach students techniques (such as object-oriented development) which are designed to help with problems of change
- Many students understandably don't see the point of these techniques - they don't understand how they help them with producing software

Teaching systems engineering

- To understand the usefulness of modern software engineering techniques, we need to teach software engineering in context.
- Students need to understand about socio-technical systems if they are to develop a proper understanding of software engineering technology

Systems engineering -objectives

- To sensitise students to the problems of developing socio-technical computer-based systems
- To give students a broad understanding of systems engineering and systems engineering processes
- To help students understand the role of software in these systems

Problems of systems engineering

- Technical problems
 - Specifying system requirements
 - Requirements volatility
 - System integration
 - System testing
- Human, social and organisational problems
 - The effects of systems on working practice
 - Understanding work
 - Organisational politics

Practical project work

- Systems engineering is a practical subject and clearly requires supporting practical work
- However, setting complete systems engineering problems is clearly impossible in the context of a university course
- Small, self-contained projects do not present systems engineering challenges

Problems with small projects

- Do not demonstrate the fact that software is an integral part of a more complex system
- Give students a misleading impression that problems are tractable and soluble.
- Do not illustrate the value of software engineering techniques
- Boring and unstimulating for many students. They do not present an intellectual challenge for the best students.

Wicked problems

- Wicked problems are problems which, by their very nature, cannot be completely specified or even understood.
- Problem understanding develops with the proposed solutions to these problems and the existence of the solution may change the nature of the problem.

Learning objectives

- Systems thinking
- Requirements compromises
- Inter-related requirements and design
- Social and political factors and their influence on requirements
- Technological choices
- Legacy systems
- Installation and deployment requirements

Automated road tolling system

- Motorway (autoroute) system where drivers pay according to the distance travelled.
- The road is divided into a number of segments and each segment has an associated tolling station
- Non-stop system - no toll barriers as are used in some European countries
- Must be retrofitted to existing motorways

General issues for discussion

- Is automated road tolling a good way to raise revenue for road maintenance?
- What is the best approach to use for vehicle identification?
- Who are the system stakeholders?
- What are likely to be the effects on road usage of installing a road pricing system?
- Are there ethical considerations (e.g. privacy) that should be taken into account?

Ethical issues

- Security and privacy
 - The system can, in principle, track people's movements around the country.
- Speeding
 - The system can, in principle, compute the vehicle speed between toll stations and therefore enforce speed limits
- Traffic displacement
 - The system may cause a displacement of traffic and associated disruption to non-toll roads

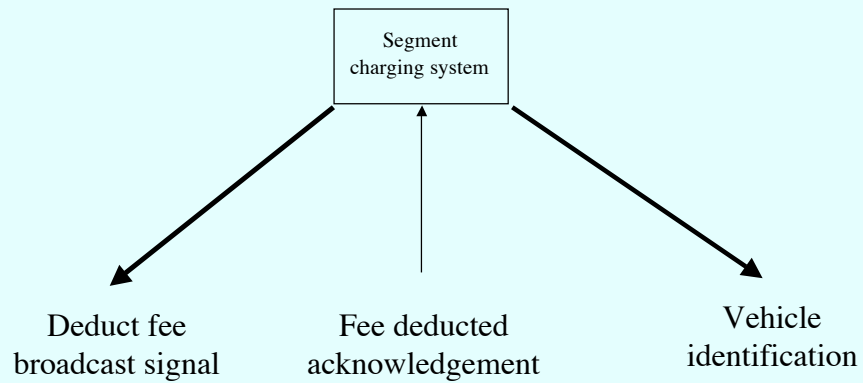
Overall system solution

- In-car unit with pre-payment smartcard that is automatically debited when passing a tolling station
- Automated number plate recognition for cars without in-car unit
- Links to national vehicle licencing system for identification
- Management and maintenance centre

System organisation

- A detection and charging system is mounted above each lane of traffic at the start of a chargeable segment.
- System includes:
 - Transmitter broadcasting a signal which is detected by the vehicle and which causes the fee for that segment to be deducted
 - Receiver which receives signals from the vehicle acknowledging receipt of transmitted signal
 - Number plate recognition system which reads the number plate if no acknowledgement is received

Schematic model of system

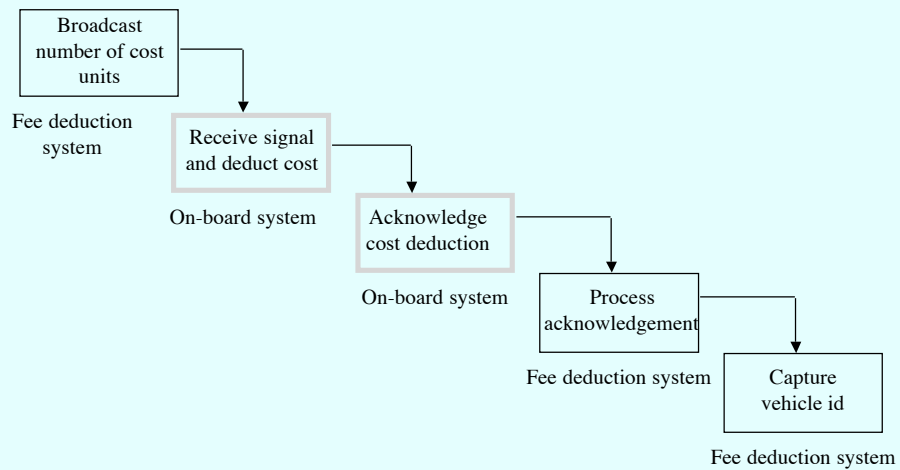


©lan Sommerville 1998

Learning from the impossible

Slide 15

Conceptual design



©lan Sommerville 1998

Learning from the impossible

Slide 16

Process issues

- Students work in teams of 3 or 4
- In-class general discussion of the system and the issues involved
- In-class team working to derive initial solution proposals with input from the instructor
- No CASE tools - solutions are prepared on large sheets of paper
- Public discussion of solution proposals

Project report

- The report has to be presented as an outline document that might be presented to technologically-literate decision makers
 - Introduction
 - System organisation
 - System architecture
 - Hardware requirements
 - Software requirements

Problems with this approach

- Many wicked problems require extensive domain knowledge for students to understand the problem.
- Transport systems are the most suitable because students can relate directly to them.
- Students are not used to handling problems with no neat solution. They cannot tell when they have 'finished' the work.

Conclusions

- Wicked problems are very valuable in contributing to the student's overall education.
- Real-world problems make courses more relevant and more stimulating for the students.
- Students develop core skills of problem analysis and presentation