

Intelligent Urban Energy Systems – Challenges and Opportunities

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Intelligent Urban Energy Systems | Key Drivers

Cities face an unprecedented set of existential challenges. New thinking is required to guide their planning, management and operation in the future

Cities are key concentration points

- Majority of the world's population already live in cities, and this trend is accelerating
- Cities directly and indirectly account for ~70% of CO₂ emissions
- Cities are the crucibles of economic, institutional and cultural value

Cities are uniquely vulnerable

- Ageing infrastructure and supply networks
- Hostile threat
- Natural hazards

Cities are under enormous pressure to change

- Broken functional and governance models (e.g., transport, healthcare, water resource management)
- Energy security
- Adaptation to climate change

These practical challenges in turn give rise to some fundamental research challenges

Holistic understanding

- Traditionally, the different sub-systems within cities (e.g., transport, water, waste, energy etc.) have been developed and operated independently
- This is no longer a tenable approach – we need the capability to understand cities holistically

Information

- To support this holistic perspective we need a step change in the information available on the function and performance of cities and the activities within them, both historic and real time

Decision support

- New understanding and data need to be translated into effective decision support that catalyses behavioural innovation and adaptation
- This capability needs to be available at all levels from the individual citizen to corporate and government entities

New opportunities exist to address these research challenges through harnessing some key emerging capabilities

Pervasively sensed systems

- Convergence of developments in sensors systems, positioning, communications and ubiquitous computing
- Embedded intelligence in our bodies, homes, and workplaces, our transport and civil infrastructure and the natural environment

Integrated urban systems modelling

- Advances in multi-scale methods and the assimilation of complexity science into engineering are beginning to enable the development of models that are capable of dealing simultaneously with highly complex, multiple sectoral systems

Deep customisation and personalisation in decision support tools

- Advances in behavioural modelling, machine learning and control theory are enabling the development of highly customisable decision support tools
- Web service technologies allow flexible packaging, discovery and composition of decision support components

Pervasive Sensing | Pervasive Mobile Environmental Sensing Across a Grid Environment (MESSAGE)

Vision

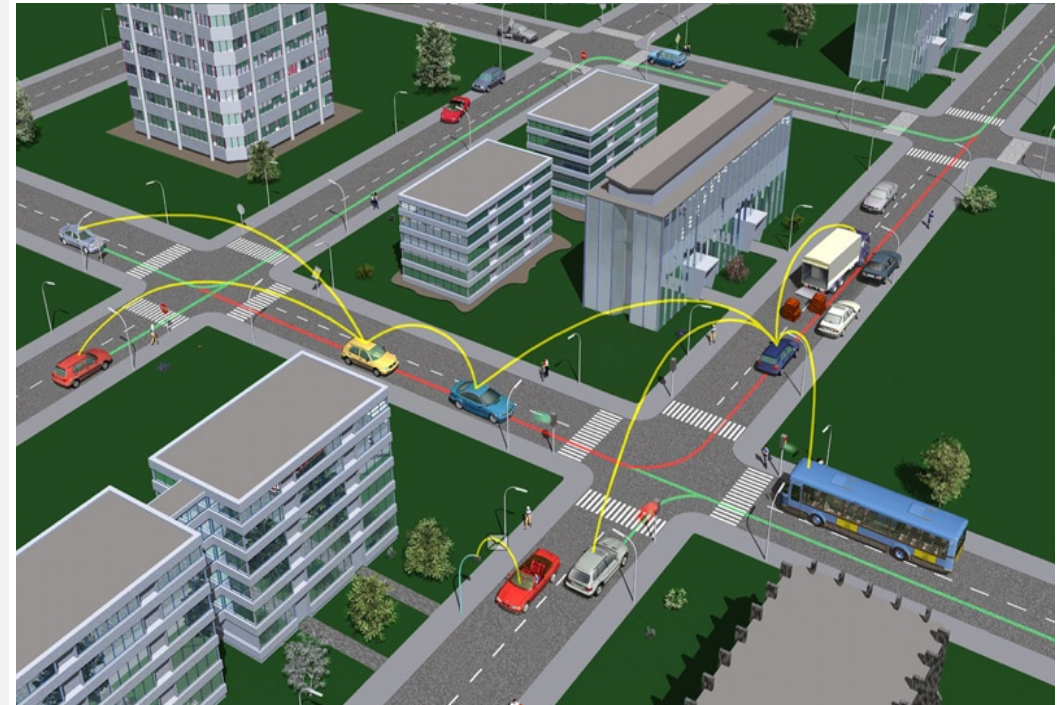
- Create an entirely new sort of data collection infrastructure to manage traffic related emissions to support research and practice

Implementation

- Network of heterogeneous fixed and mobile air quality sensors on infrastructure, vehicles and people
- Sensors communicate via wireless networks
- Positioning via GPS + wireless & cellular ranging
- Integration of processing along the data path

Application

- Improved pollution hot spot prediction, detection and mitigation for Local Authorities
- Improved air quality information for individual travellers
- Monitor exposure and health impacts



Integrative modelling | BP Urban Energy Systems Project

Vision

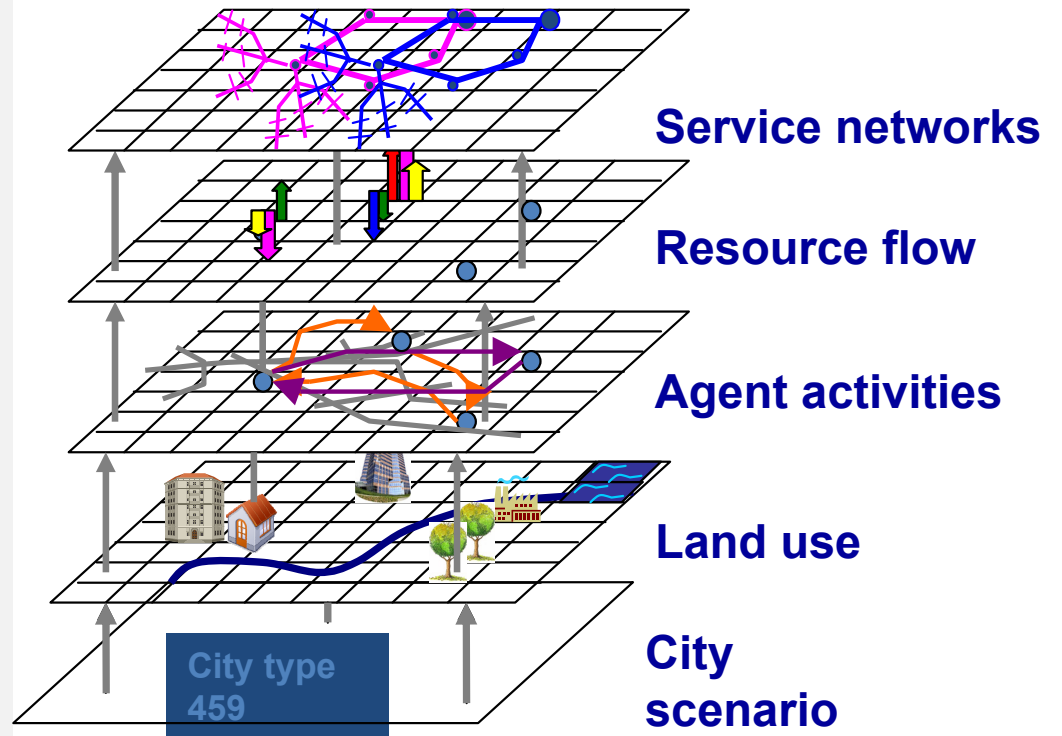
- Create integrated model of energy supply, distribution and use in a city
- Quantify benefits of integrated design and Identify pathways to implementation

Implementation

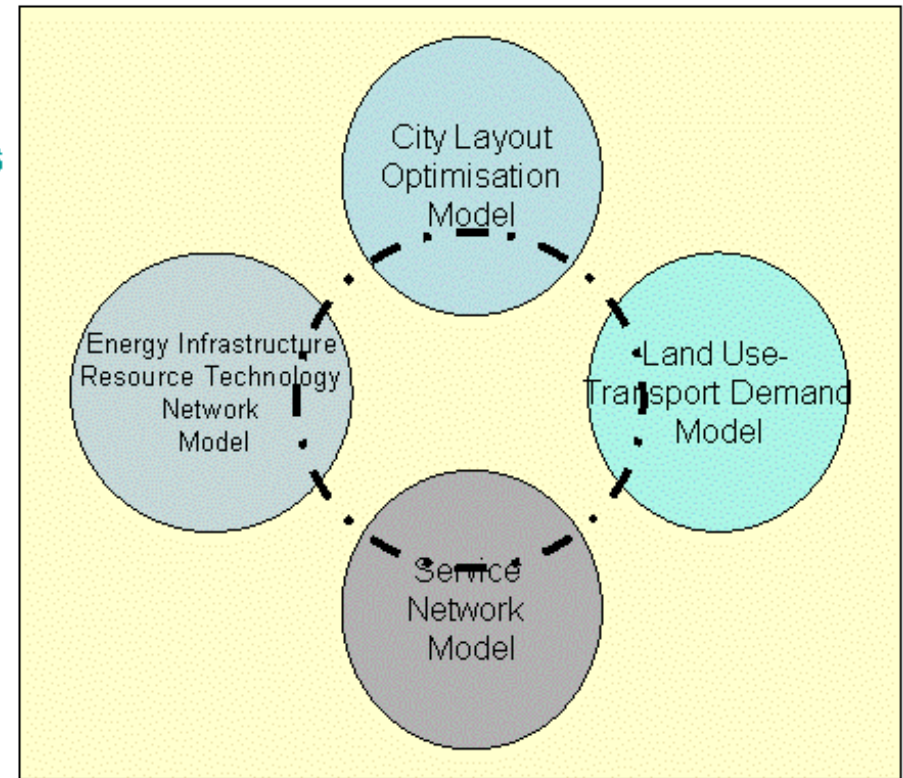
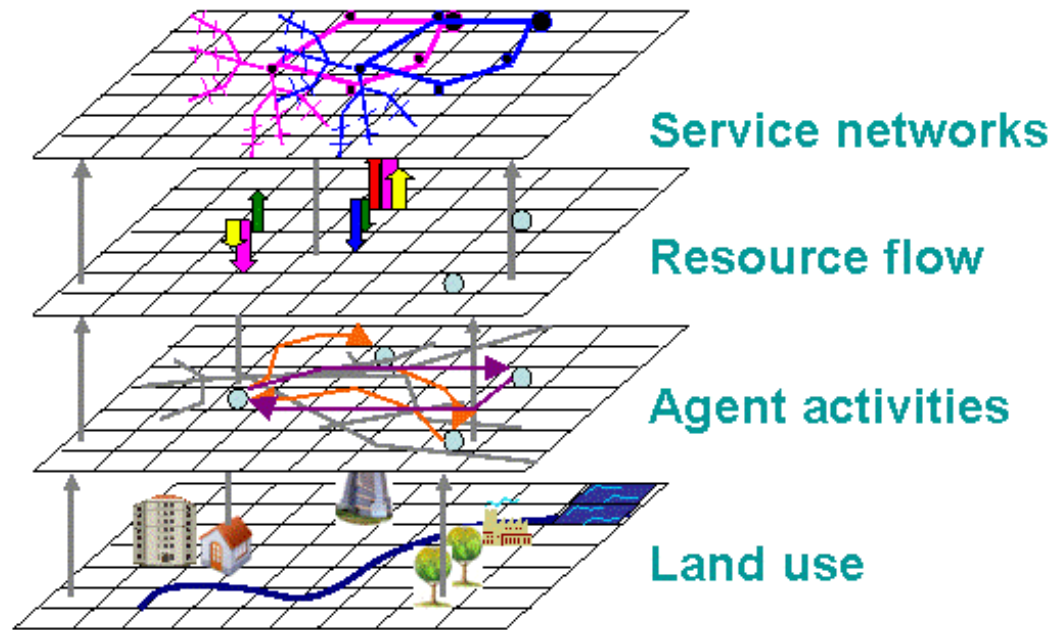
- Unique multidisciplinary collaboration – energy, transport, water, wastes, business
- Develop novel agent-based model of the complete urban system
- Linked to state of the art optimisation, for planning and design
- Leveraging state of the art methods in transport, land use and energy systems modelling

Application

- A number of case study applications are underway both 'new build' and existing cities (including London)



Integrative modelling | BP Urban Energy Systems Project



Decision support | Intelligent Decision Support for Congested Networks (FREEFLOW)

Vision

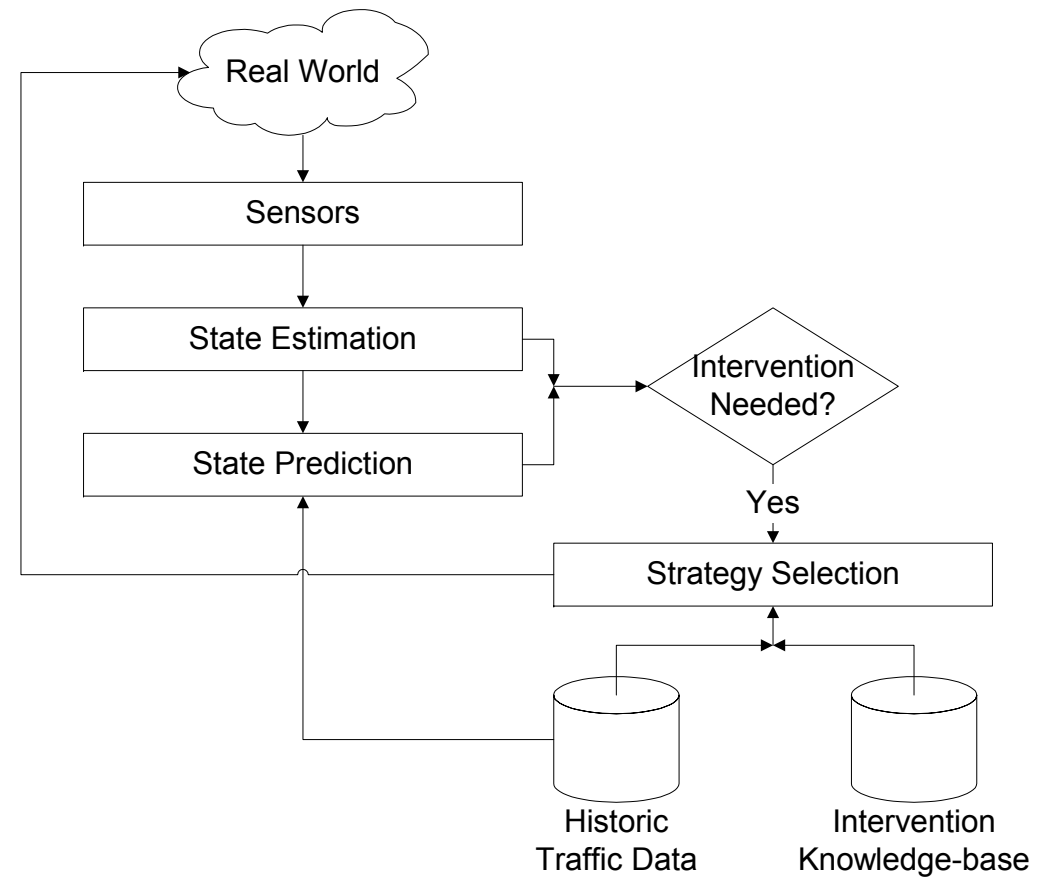
- Develop a platform for traffic intelligence, leveraging situational awareness technologies from the military domain

Implementation

- Traffic sensor processing and data fusion + network state estimation and prediction (e.g., where are the queues/incidents, are they growing or clearing?)
- Strategy development and selection (e.g., what should we do, what worked in the past, what does modelling tell us?)
- Tools for integration, visualisation and decision support (e.g., how do I get at and use all this stuff?)

Application

- London, York and South East England motorway network



Key building technological building blocks are in place but much work still to be done to

Key capabilities

- Pervasive sensing
- Integrative (cross-sectoral) modelling
- Decision support

If we can get it right, there are some potentially big wins

- Vehicle-to-grid integration to support large scale deployment of electric vehicle fleets
- Distributed, micro-generation
- Pervasive co-operative systems

But also some new challenges e.g.,

- More closely coupled/integrated systems will create new vulnerabilities

Thank you

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