How Technology Can Inform Public Policy for Smart Cities

Notes from the frontier

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All images from Wikipedia unless otherwise noted
MANY PROBLEMS FACING CITIES TODAY

Health and substance abuse

Changing demographics

Lack of affordable housing and homelessness

Infrastructure management

Environmental degradation (soil, water, air)

Energy use and carbon footprint

Resilience to climate change
SOME CAN BE SOLVED BY ‘SMARTNESS’

Health and substance abuse

Changing demographics

Lack of affordable housing and homelessness

Infrastructure management

Environmental degradation (soil, water, air)

Energy use and carbon footprint

Resilience to climate change
DIGGING DOWN...

Infrastructure management/mismanagement
- transportation networks
- water supply
- stormwater and sewage
- waste management and recycling
- leaf and snow clearance
- tree cover and parks
- parking

Energy use and carbon footprint

Resilience to climate change
AT A HIGH LEVEL...

Moving

- Energy
- People
- Water
- Waste

Spending

- Money
- Energy
- Carbon

With susceptibility to shocks
CAN WE TREAT THE CITY AS AN ORGANISM?

Study the movement of energy, materials, people, waste
The Metabolism of Cities

by Abel Wolman

The metabolic requirements of a city can be defined as all the materials and commodities needed to sustain the city’s inhabitants at home, at work and at play. Over a period of time these requirements include even the construction materials needed to build and rebuild the city itself. The metabolic cycle is not completed until the wastes and residues of daily life have been removed and disposed of with a minimum of nuisance and haz-
Figure 2: Study of the urban metabolism of Brussels by Duguayaud and Denayer-De Smet, 1977 (http://infodiagrama.blogspot.nl)
Estimated U.S. Energy Consumption in 2017: 97.7 Quads

Data is based on DOE/EIA-0584 (2017). In this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices this work was performed. This data was created in 2017 to reflect changes made in mid-2016 to the Energy Information Administration’s analytical methodology and reporting. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. Net efficiency is estimated as 46% for the residential sector, 44% for the commercial sector, 28% for the transportation sector, and 4% for the industrial sector which was updated in 2017 to reflect DOE’s analysis of manufacturing. Totals may not equal use of components due to independent rounding. LLNL-ANL-014941
Figure 1: Sankey diagram of Quebec's energy system in 2012

Fig. 2. Key metabolic processes of study system of Toronto neighborhoods
sustainable urban futures will require a fundamental transformation of existing production and consumption patterns in cities, and that looking into how these patterns are organized into flows—of materials, energy, people, meanings, and power—is a fruitful avenue to investigate such transformation.

Data Acquisition

The biggest challenge of this study was to find reliable data. Some of the current information on consumption of water, food, and energy at the neighborhood level is scarce and therefore the metabolism of neighborhoods is established with the data available. For the system defined above, data are collected from various available data. For MFA to develop, however—and it should conceivably be conducted every year or at the very least every five years for effective environmental policies to be implemented—it will be necessary for government to improve data production, collection, and availability.

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(1) Lack of data: Despite the acknowledged importance of cities for the overall volume of socio-economic material and energy use, periodically available and harmonized datasets are provided by statistical offices almost exclusively for the national level. Therefore, any attempt to generalize patterns and trends of urban specific resources use from the literature struggles with incomplete or incommensurable data.

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comes. Data gaps, omitted/hidden upstream flows, uncertainty regarding the appropriate scale of analysis, and segregated information sources continue to constrain fine accounting of the urban metabolism of cities. No studies have yet been able to describe flows into a city and the waste sinks in a way that correlates those flows with the specific residents and their activities, let alone a cradle to grave accounting of the inputs. For example, few cities have data about trash generation by fine-grained geographic scale or by land use type.
Open data initiatives from all levels of government
BUT THERE IS MORE... 

Internet of things
- Allows pervasive measurement, communication, monitoring, and control
MICRO SENSORS
Pervasive Control
BUT ALSO…
BUT THERE IS MORE . . .

Internet of things

Data science
Data Science

- Scientific Methods
- Visualization
- Statistical Modeling
- Statistical Computing
- Real-world Applications
- Data Consulting
- Data Technology
- Data Research

BUT THERE IS MORE... 

Internet of things 
Data science 
Blockchains
WHAT IS A BLOCKCHAIN?

A globally visible ledger that is owned by no one but can be trusted by everyone
ORIGINS
HOW TO BUY A HOT DOG
HOW TO BUY A HOT DOG

Go to the bank
HOW TO BUY A HOT DOG

Go to the bank

Get $5

- Bank reduces your account balance by $5
HOW TO BUY A HOT DOG

Go to the bank

Get $5

- Bank reduces your account balance by $5

Pay $5 to vendor and get a hot dog
HOW TO BUY A HOT DOG

Go to the bank

Get $5
  • Bank reduces your account balance by $5

Pay $5 to vendor and get a hot dog

Vendor deposits $5
  • Bank increases vendor’s account balance by $5
HOW TO BUY A HOT DOG

Go to the bank

Get $5
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Pay $5 to vendor and get a hot dog

Vendor deposits $5
  • Bank increases vendor’s account balance by $5

It’s all about manipulating a ledger!
  • No need for bank notes
BUYING WITH A LEDGER

Transfer hotdog to buyer

Transfer $5 to vendor
BUT...

What if the ledger is corrupted?
CS TO THE RESCUE!

Distribute the ledger

- A copy of the ledger is stored at many servers
CS TO THE RESCUE!

Distributed

Transparent
- Everyone can easily validate transactions
- Though private transactions possible
CS TO THE RESCUE!

Distributed

Transparent

Immutable

- Once in the ledger, information cannot be changed
CS TO THE RESCUE!

- Distributed
- Transparent
- Immutable

Secure
- Non-repudiable
- Allows a certain fraction of servers to be hacked/become untrusted
NO NEED FOR A TRUSTED ENTITY!
A globally visible ledger that is owned by no one but can be trusted by everyone
BLOCKCHAINS FOR SMART CITY DATA

Blockchains can hold consent for data use

Proves that data access is valid

Fills the privacy gap
TO SUM UP

Cities are metabolic creatures
and to manage them, we need to understand the flow of energy, materials, and people
So far, a lack of data and analytical capabilities
This will change with IoT and Data Science
But there is a danger with unrestricted sensing
So we will also need blockchain to protect privacy
MESSAGE TO POLICY MAKERS

Technology is poised to fill data gaps

Evidence-based policy-making will soon be possible

- without compromising privacy (too much)