Consumption in an IoT world: Benefits, Challenges and Implications for Sustainable Cities

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Agenda

- Background: from influencing to journeying consumption
- The impact of Internet of Things (IoT) on consumer journey
- Modelling consumption journey
- Implications for Sustainable Cities

The traditional paradigm for understanding consumer behaviour

- Consumers subject to the influence of marketing actions: promotions, advertising, etc.
- Consumers are only observed through their purchases
- Consumption is mostly a result of choices
- Consumption a result of pushing consumers

The transition: Customer journey

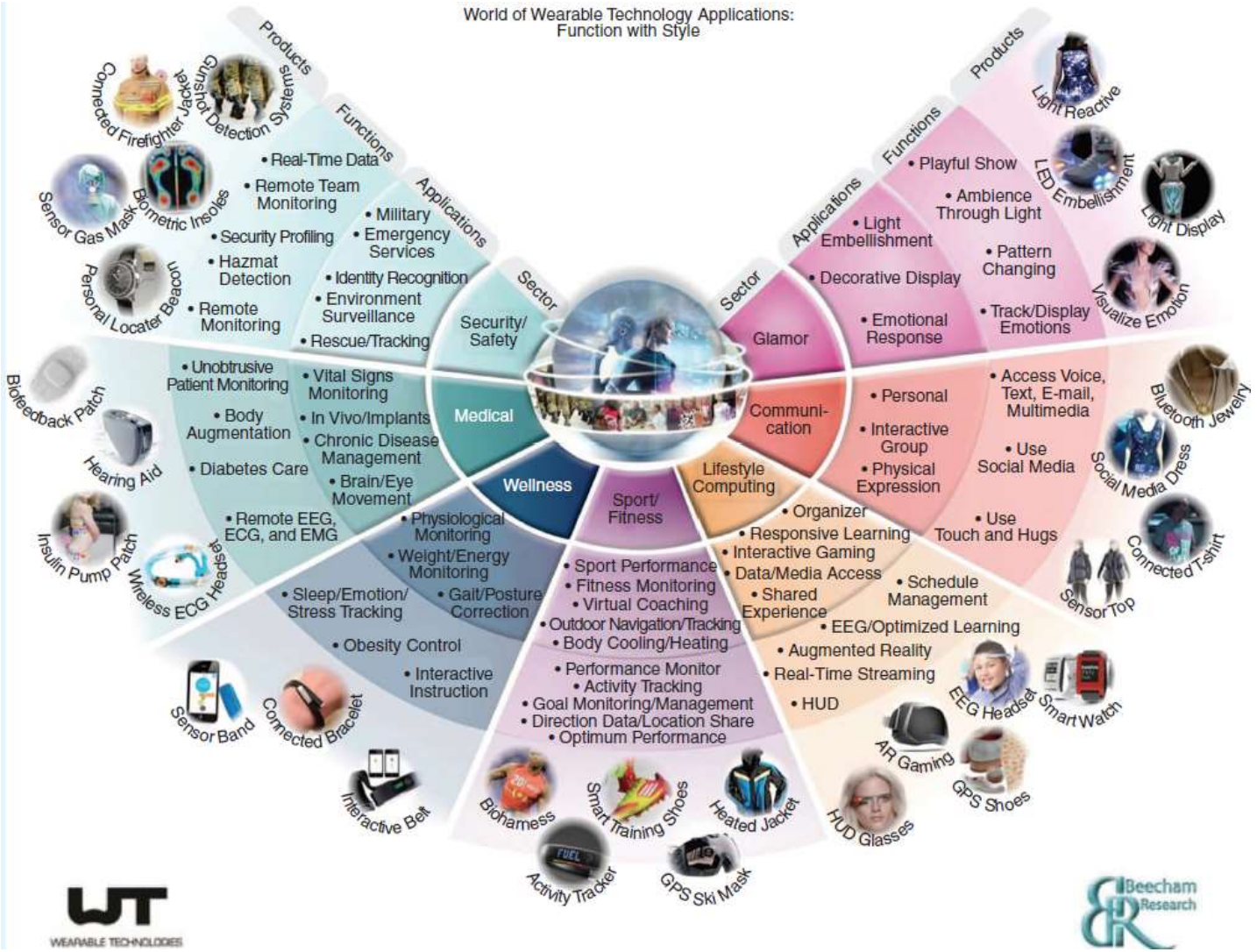
- Customer journey involves continuous engagement with the consumer through touchpoints
- Touchpoints are part of the processes that customers have with a product and service over time: pre, during and post-purchasing
- Customer behaviour during the journey is the result of expectations, perceptions and experience obtained with each engagement
- Measurement of the experience is multidimensional: sensory (sense), affective (feel), cognitive (think), physical (act) and social-identity (related).

The ecosystem of IoT

- Everyday objects can be augmented with RFID tags and sensors to become Internet-connected constituents (ICC) that generate real-time data
- The analysis of the metadata from ICCs will help to make sense of local situation and context
- Sensors and sensor networks can detect emotions generating experiential data
- Quantitative data on consumption and experience leads to visibility of consumption experience
- Integration of multiple sources including environmental information

Ng and Wakenshaw (2017) The Internet-of-Things: Review and Research Directions

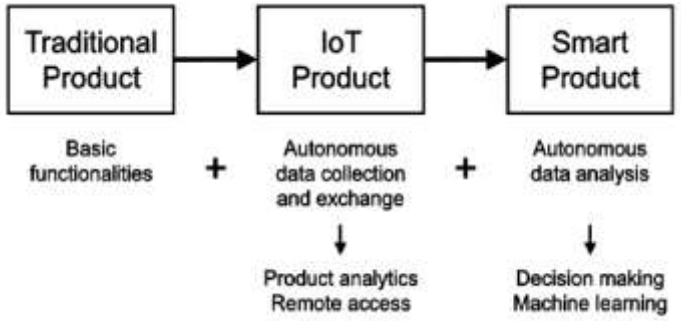
Wearables and the IoT

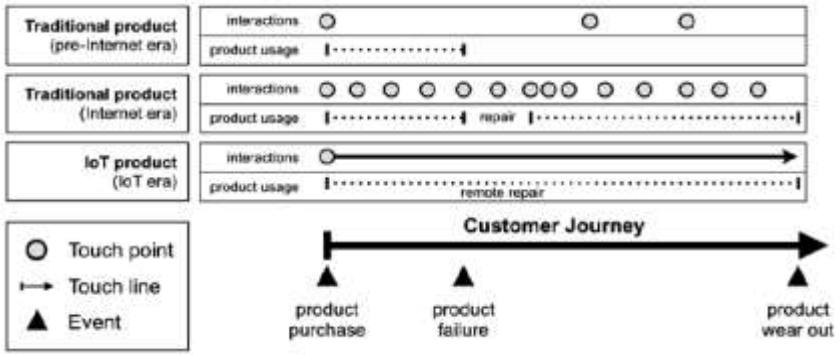


Wei (2014) How wearables intersect with the Cloud and IoT

From touchpoints to touchlines

- Smart products under IoT can interpret usage data, learn and adapt to customer preferences over time.
- IoT products capture product usage and transmit these data to companies. These data can help firms to change product features toward customer individual needs.
- Marketing analytics in real time using machine learning and deep learning

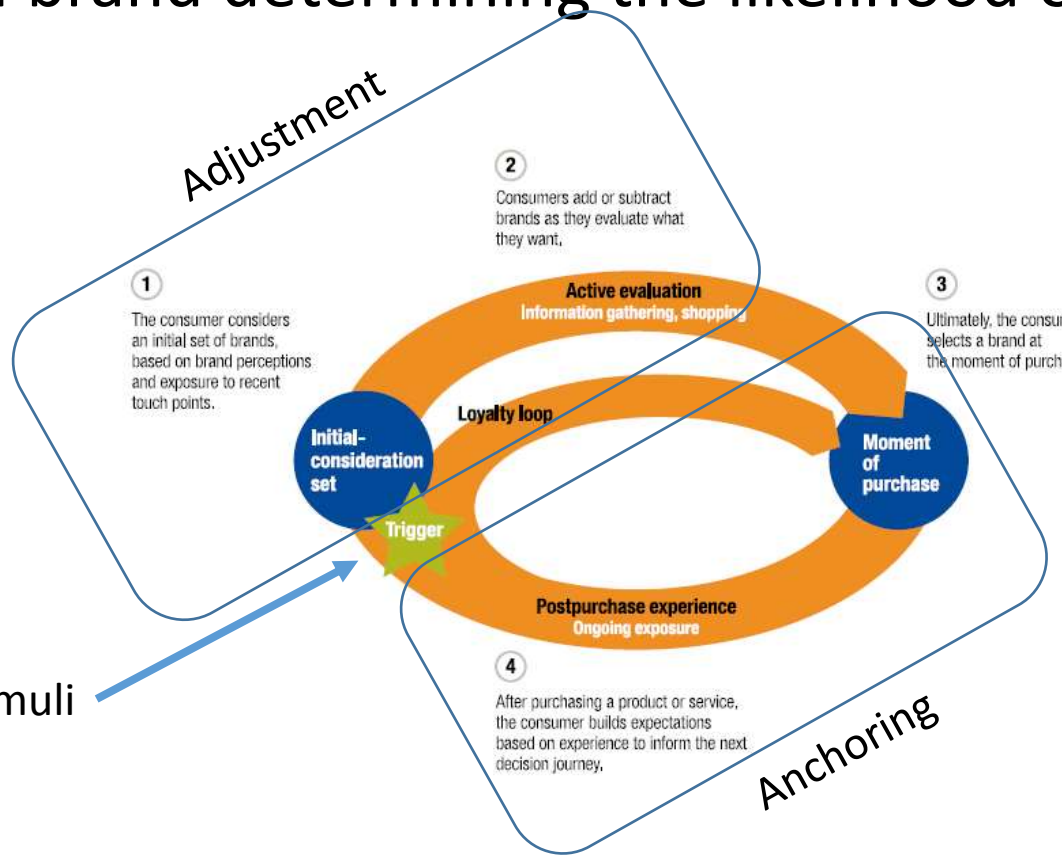




Decker and Stummer (2017) Marketing management for Consumer Products in the Era of the IoT – figures 1 and 3

Consumer decision journey – a continuous process

- Accumulated impressions of brands and products determine the initial consideration set of purchasing options (adjustment)
- After the purchase and trial, consumers generate loyalty towards the product and brand determining the likelihood of buying again (anchoring)



Sector	Share of purchases, %			Average number of brands	
	Initial consideration	Active evaluation	Loyalty loop	In initial-consideration set	Added in active consideration
Autos	63	30	7	3.8	2.2
Personal computers	40	24	27	1.7	1.0
Skin care	38	37	25	1.5	1.8
Telecom carriers	38	20	42	1.5	0.9
Auto insurance	13	9	78	3.2	1.4

Irrational: push

Functional: pull

Stimuli

Court et al (2009) The consumer decision journey. McKinsey Quarterly

A flow of continuous data will help to

- Find anchor and adjustment processes
- Identify the correct stimuli saving resources and avoiding confusing consumers
- Identify timing to provide the goods and services
- Discover new consumption activities that require complementary goods and services

Examples of anchoring-and-adjustment are pervasive

- Energy use: heating, transportation, lighting
- Shopping trips: daily goods, personal consumption goods
- Entertainment: favourite restaurant/pub, sports, movie theatre
- Lifestyles: walking, cycling,

The implications for sustainable cities

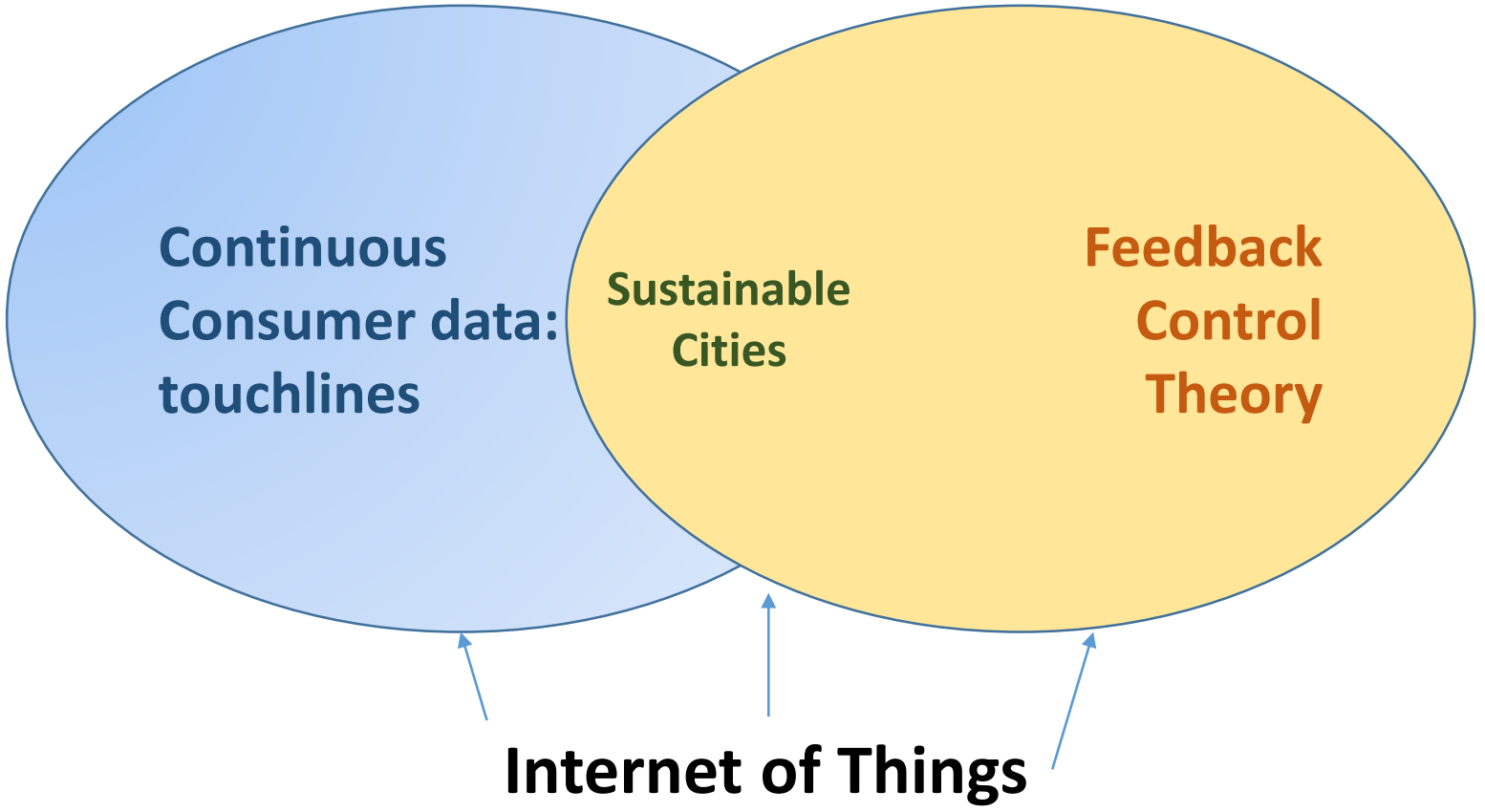
Cities are complex social and economic systems

- Cities, as social systems, are not simple systems where one system state dominates the behaviour.
- Cities have multiple interacting feedback processes and system states.
- Cities contain positive feedback processes driving growth processes and goal-seeking feedback processes driving equilibrium and stagnation.

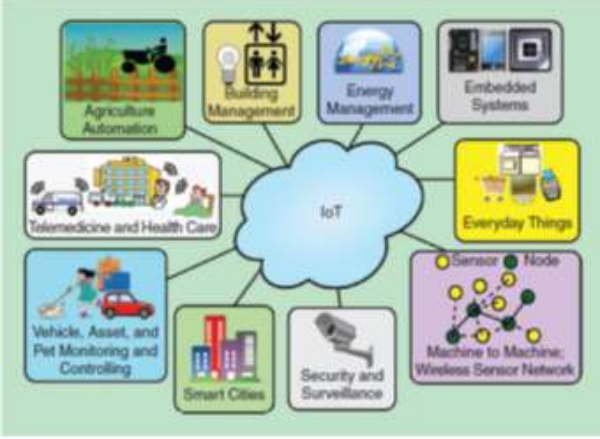
- Cause and effect are not closely related in time or space.

- Causes that appear to be plausible may be symptoms.
- High degree of time correlation between variables can lead to make spurious cause-and-effect associations.

The integration of disciplines for sustainable cities



Characteristics of IoT Infrastructure



- Heterogeneous devices (sensor to computer)
- Resource-constrained (computing power)
- Spontaneous interaction (sudden interactions due to movement, communication ability)
- Ultra-large-scale network and large number of events (multiple equipment connected in a place which is larger than conventional networking systems).
- Dynamic network and no infrastructure (mobile, wirelessly connected and resource constrained)
- Context aware (sensors generate contextual data that needs interpretation)
- Intelligence (intelligent devices)
- Location-aware (spatial information about objects and sensors is critical)
- Distributed

Mohanty et al (2016) and Razzaque et al (2016)

Challenges for Managing IoT-driven systems

- Many systems use feedback control theory to provide robust performance such as stability, overshoot, settling time and accuracy
- Openness and scale create difficulties for this method because the model of the system is constantly changing and there are a large number of control loops interacting.
- Four type of interactions for humans-in-the-loop:
    1. Humans directly control the system by adjusting the anchors of the algorithms
    2. System monitors human passively and takes appropriate actions
    3. Physiological parameters are modelled, reports the results and waits for further commands
    4. Hybrids of 1, 2 and 3

Stankovic (2014) Research directions for the IoT

Challenge: how to derive models of human behaviours on-real time

- System identification techniques to create system models:
  - Order and types of equations
  - Adequate testing inputs
  - Suitable output variables
  - Validation against human traits

  Clustering, data mining, inference and first principle models based on human physiology and behaviours

- Process of abstraction from raw data to meaningful information

- Robust systems require predictive models to avoid problems before they occur

Stankovic (2014) Research directions for the IoT

Challenge: how to incorporate human behaviour into feedback control

- Location of human models:
  - Outside the loop
  - Inside the controller
  - Inside the system model
  - At various levels in hierarchical control

- Stability, accuracy, setting time and overshoot properties as the system and human behaviour evolve.

Stankovic (2014) Research directions for the IoT

Adjustment towards sustainable anchors

- Following ‘anchoring-and-adjustment’ processes, it is clear that the sustainability will depend on the existing anchors on the diverse stakeholders in the city in terms of critical dimensions:
  - Recycling
  - Transportation
  - Energy
  - Food consumption
  - Alcohol consumption
  - Antisocial behaviour
  - Investments in business and housing

- Anchoring-and-adjustment works differently if the anchors are self-generated versus provided as it impacts on the motivation to adjust towards the anchor (Simmons et al, 2010).

Thank you for attending

Questions