Mobile and Ubiquitous Computing 2022-2023

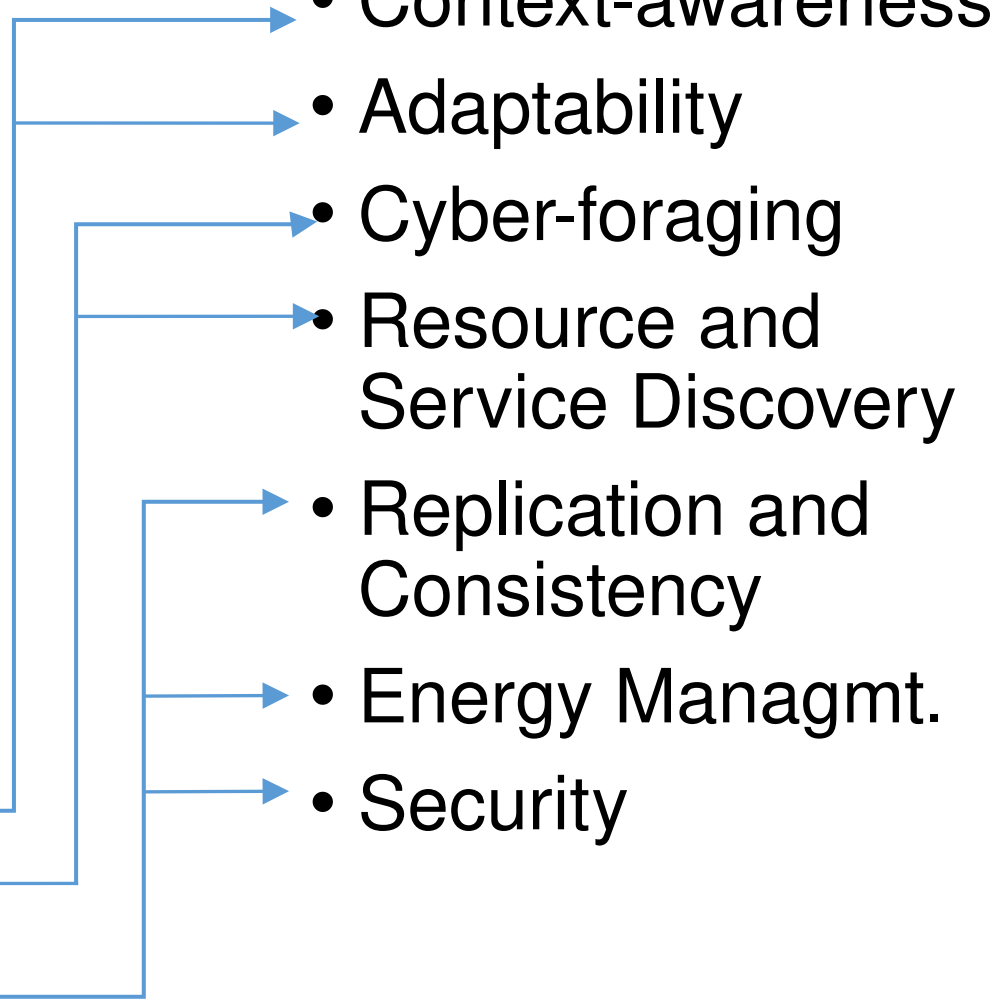
Definitions, Ubiquitous and Pervasive Computing Overview

Evolution

- Hardware evolution
- Ubiquity of devices
- Ubiquity nightmare
- Invisible computing
- Some examples

Goal/Requirements and Challenges

- Goal: invisible computing
- Requirements common to other areas:
  - Scalability in the large
  - Performance
  - Availability
- Requirements specific to CMU:
  - Support Variability
  - Deal with Resource Constraints
  - Provide Constant Access to Devices
  - Support Localized Scalability



Basic Definitions

- Distinction from classical distributed systems
- Fundamental concepts

- Mobile computing
- Ubiquitous computing
- Pervasive computing

- Localized scalability
- Smart spaces

Mobile Computing

- Mobile computing is a computer science and engineering domain that deals with:
  - computing and communication software and hardware aspects
  - related to the use of mobile devices (e.g smartphones, tablets, laptops, etc.)

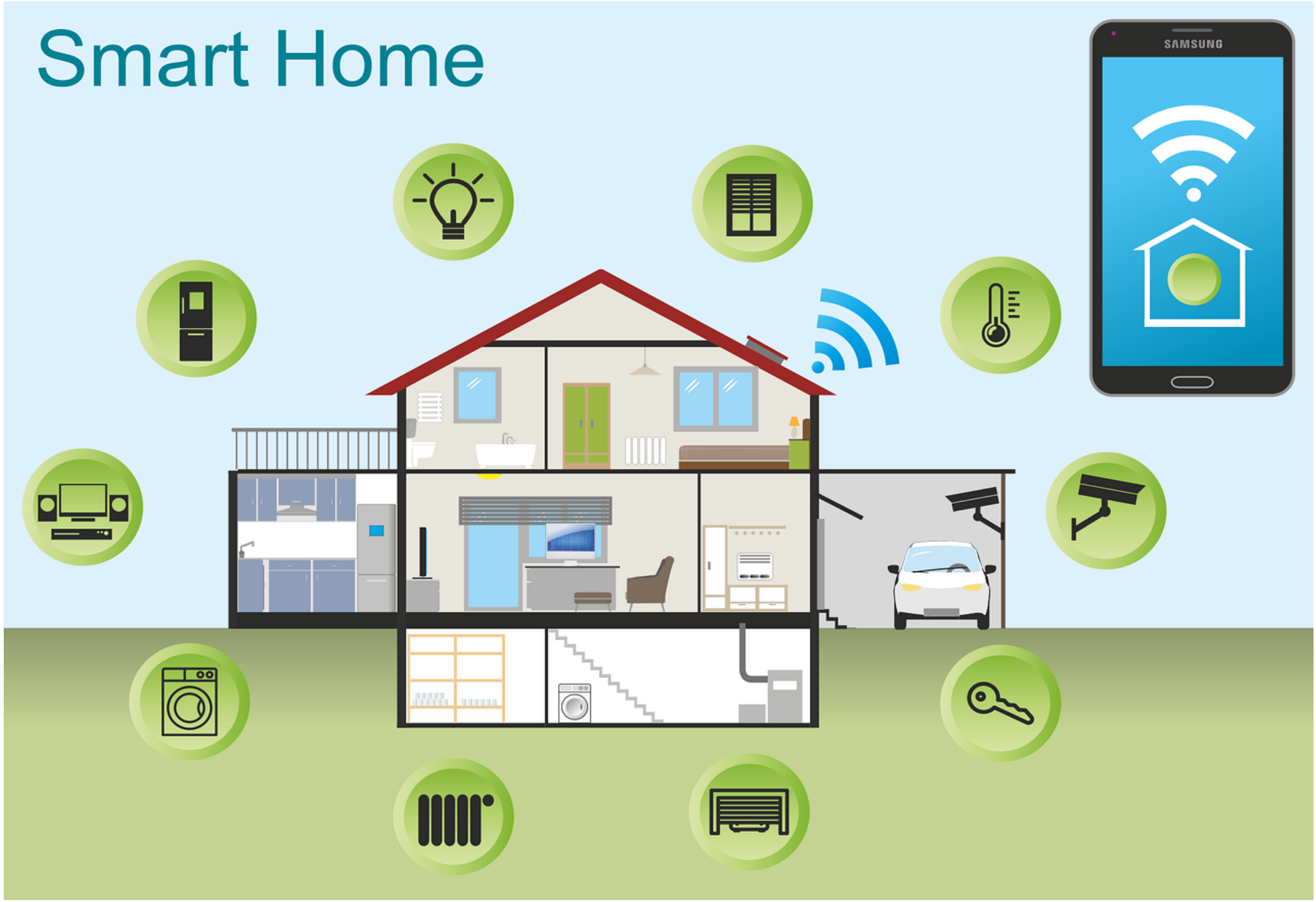
- This domain includes several areas:
  - We are concerned with **software** (hardware and network protocols are out of the scope in this course):
    - Middleware, sensors, distributed support, application support.

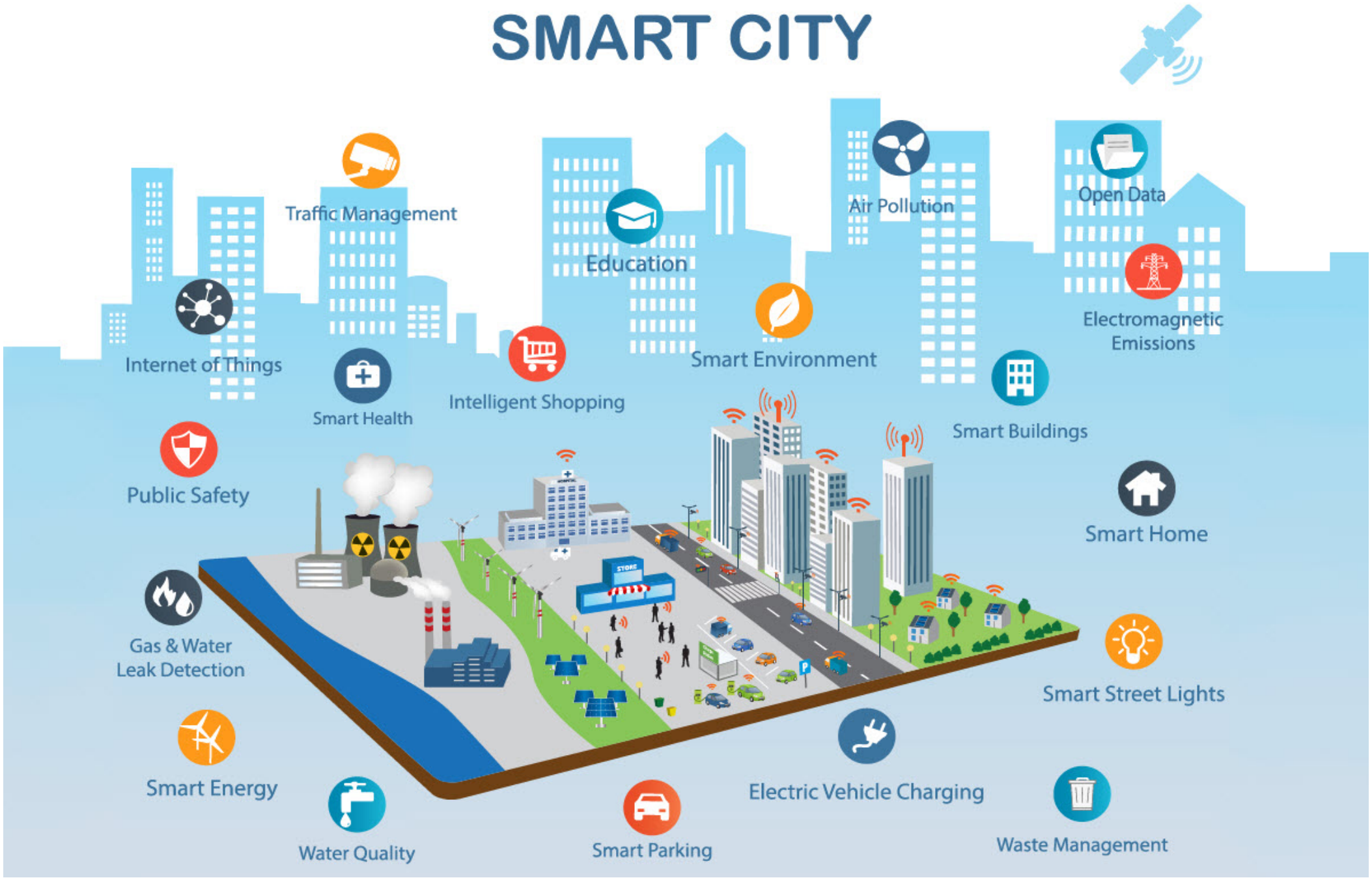
- Thus, in the scope of this course, we refer to mobile and ubiquitous computing to:
  - designate all **system-level software issues** related to the architectural design of solutions, including applications, middleware and operating systems,
  - which allow a **mobile** device to run mobile applications efficiently, while being scalable, secure, and energy efficient.

Ubiquitous Computing

- Sometimes also designated as pervasive computing.
- Hardware evolution has created a large number of devices with a large variety in sizes, characteristics, processing power, etc. (e.g. tablets, laptops, smart-watches, etc.):
  - thus contributing to the **ubiquity of computing and communication devices** in the world
- Specifically, ubiquitous computing is a computer science and engineering domain that deals with:
  - all computing and communication software and hardware aspects
  - related to the use of ubiquitous devices
- Given that most of such ubiquitous devices are mobile, it is clear that there is an overlap between these two fundamental concepts, but:
  - in some cases, we may be in presence of an ubiquitous system in which the devices are not mobile
  - thus, we can have an ubiquitous system that is not mobile and, on the other way around, a mobile system which is not ubiquitous

Examples of Ubiquitous Environments


Smart Home
SAMSUNG


SMART CITY
Traffic Management
Education
Air Pollution
Open Data
Internet of Things
Smart Health
Intelligent Shopping
Smart Environment
Electromagnetic Emissions
Smart Buildings
Public Safety
Smart Home
Gas & Water Leak Detection
Smart Street Lights
Smart Energy
Electric Vehicle Charging
Water Quality
Smart Parking
Waste Management

Pervasive Computing

- In the literature, sometimes there is no distinction between ubiquitous and pervasive computing.

- Pervasive computing implies the **embedding of computing devices into everyday analog objects**:
  - e.g. the smart-mug that changes its color according to the temperature of the liquid it contains.

- One could be in a pervasive computing environment which is not ubiquitous:
  - unless, there are several “stupid” objects, with increased embedded computing capabilities, all over.

Pervasive Computing Examples

Mobile, Ubiquitous, and Pervasive Computing

- The concepts underlying mobile, ubiquitous and pervasive computing are mostly related to the properties of:
  - mobility (i.e., devices can be easily moved from one place to another by the user),
  - ubiquity (i.e., devices are everywhere), and
  - pervasiveness (i.e., “stupid” everyday objects with embedded computing devices), respectively.

- The most interesting scenarios are those in which a mix of these properties exist.

- The challenges being addressed, previously mentioned, apply to all such cases as they all share a common view:
  - “information at your fingertips anywhere, anytime”.

Localized Scalability and Smart Spaces

- It is the equivalent to the concept of scalability when applied to classic distributed systems:
  - the difference is that we are concerned with the large number of devices that may co-exist in a confined/small space (e.g., in a room)

- Localized scalability means that a system must scale in the local space:
  - i.e., it must be able to handle a growing amount of devices and the resulting interaction

- Such a room is also called a smart-space:
  - its “smartness” results from the existence of a large number of computing devices that, while being invisible, perform the work needed

Joseph Marie Jacquard (1752-1834)

Example: Jacquard (1/2)

Welcome to Project Jacquard - https://www.youtube.com/watch?v=qObSFfdfe7I

Example: Jacquard (2/2)

Levi's® Commuter™ x Jacquard by Google Trucker Jacket - https://www.youtube.com/watch?v=yJ-lcdMfziw