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UBIQUITOUS COMPUTING: VISION, KEY ENABLERS AND TECHNICAL CHALLENGES

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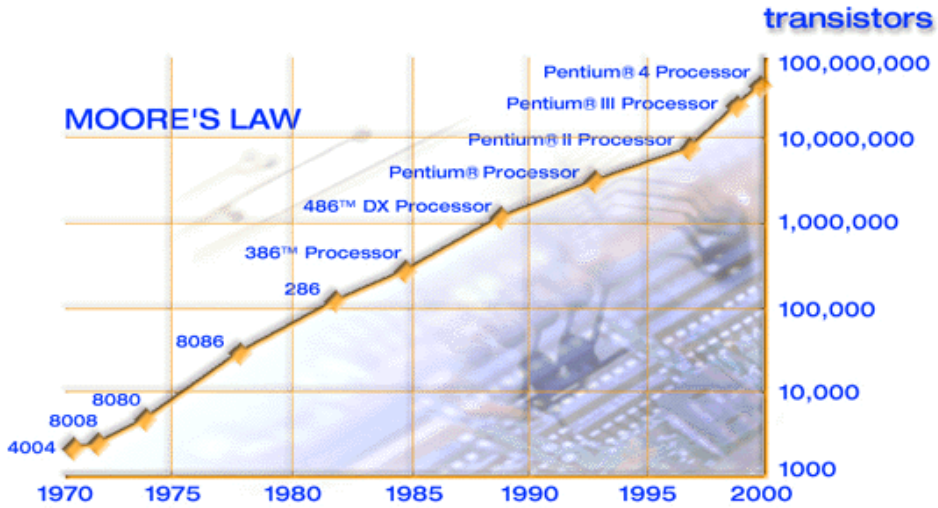
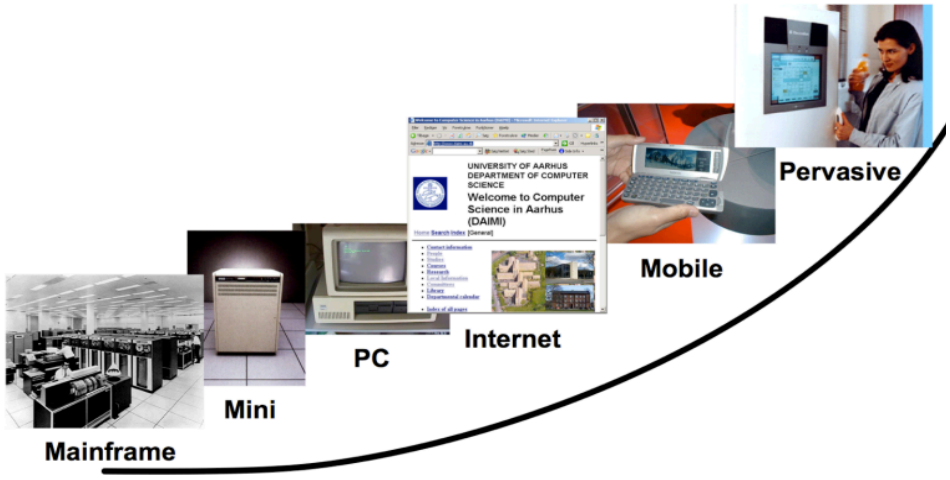
Ubiquitous Computing: vision, key enablers and technical challenges

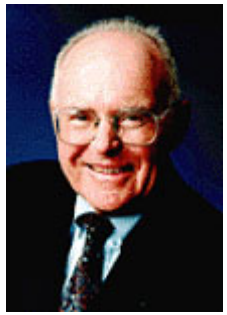
VISION

Living in an Increasingly Digital, Interconnected World

- We see (and don't see) computers in everywhere



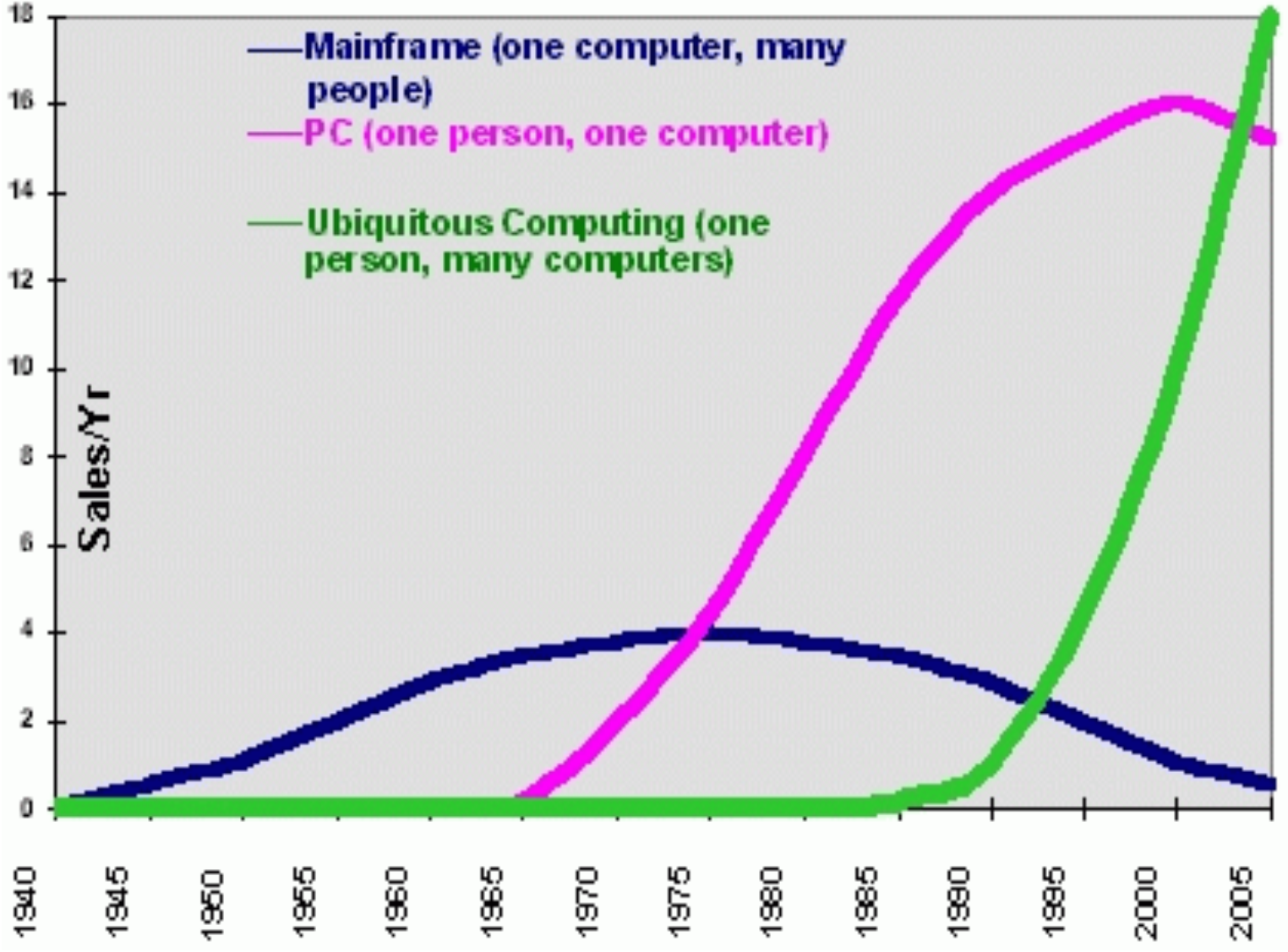




Gordon Moore, R&D director at Fairchild Semiconductor

Source: http://www.xbitlabs.com/articles/editorial/display/moore.html

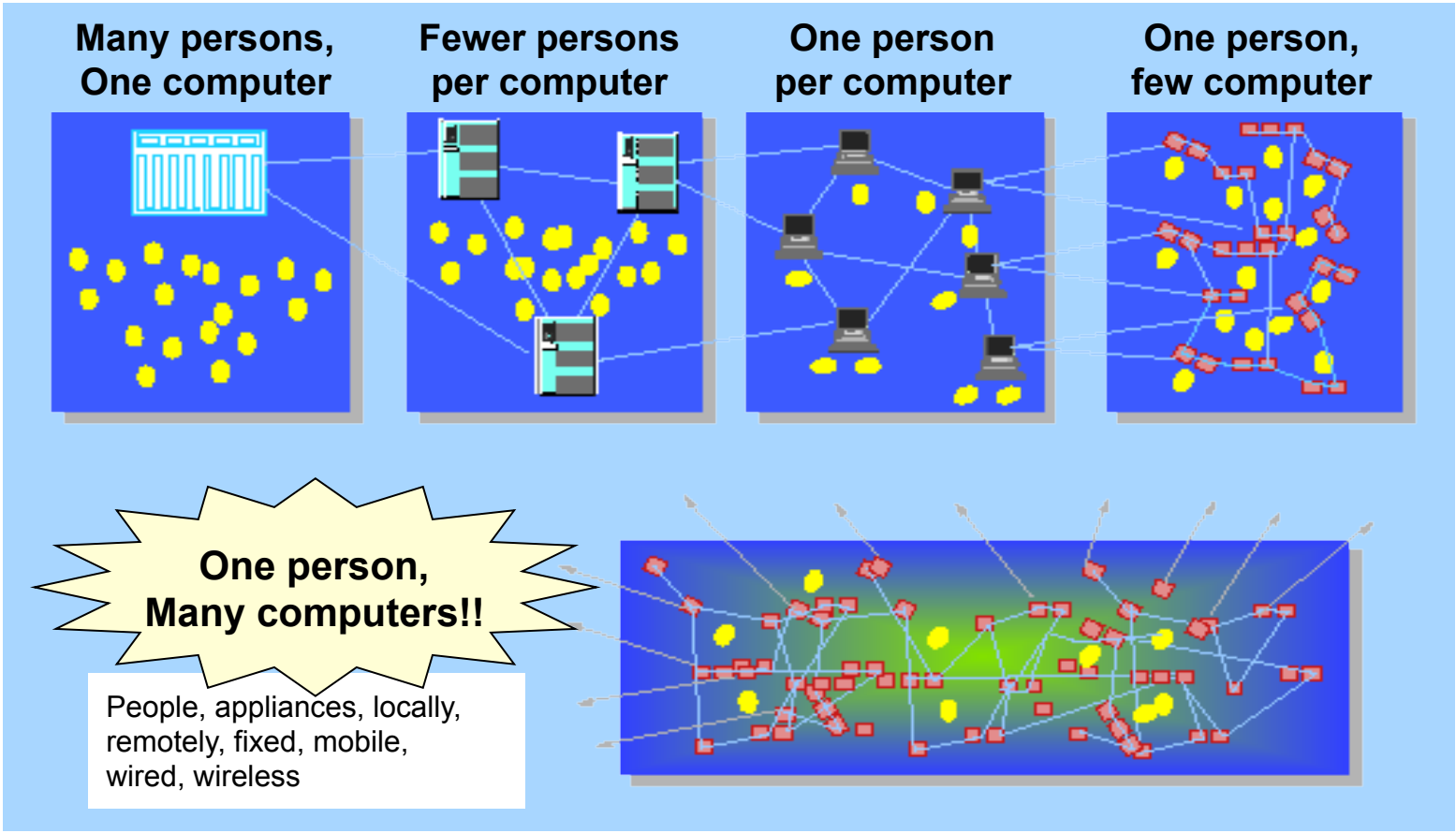
Trend: Weiser's 3 waves of computing



Source: Stefan Poslad, 2009

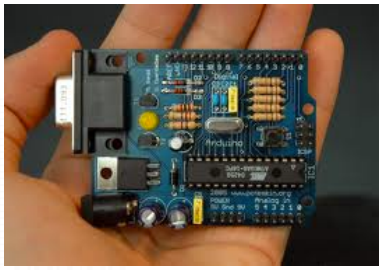
Evolution of Computing

- One-for-many to many-for-one
- The same computer used by many users



Slide by Dongman Lee, KAIST

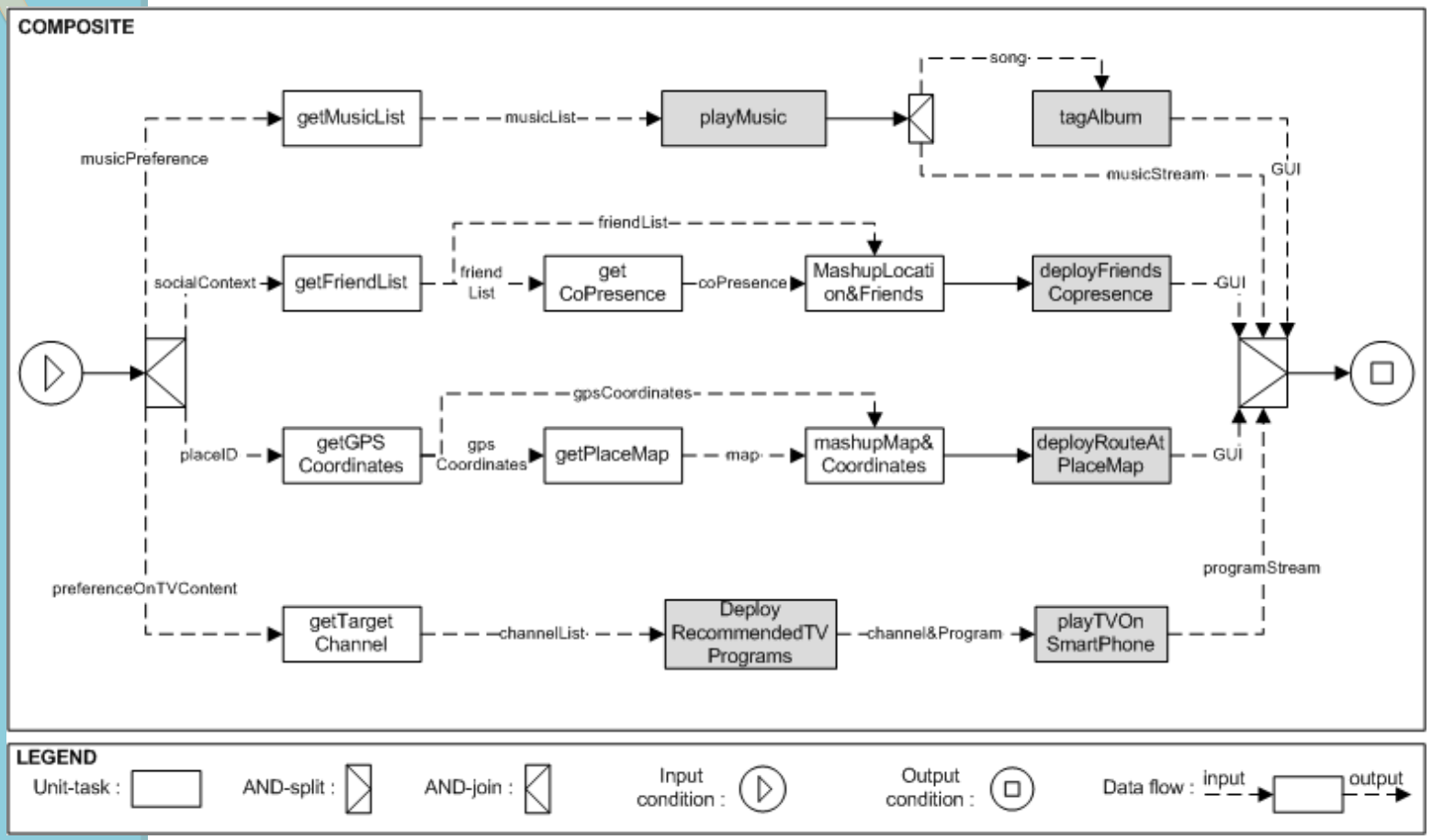
One User has Many Computers

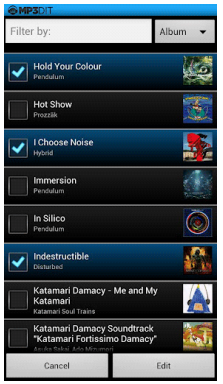


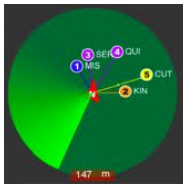
The Same Computer Used by Many Users

Ubiquitous Business Process

People needs to access business processes in mobile and ubiquitous environments







Source: own elaboration

What We Are Already Capable To Do

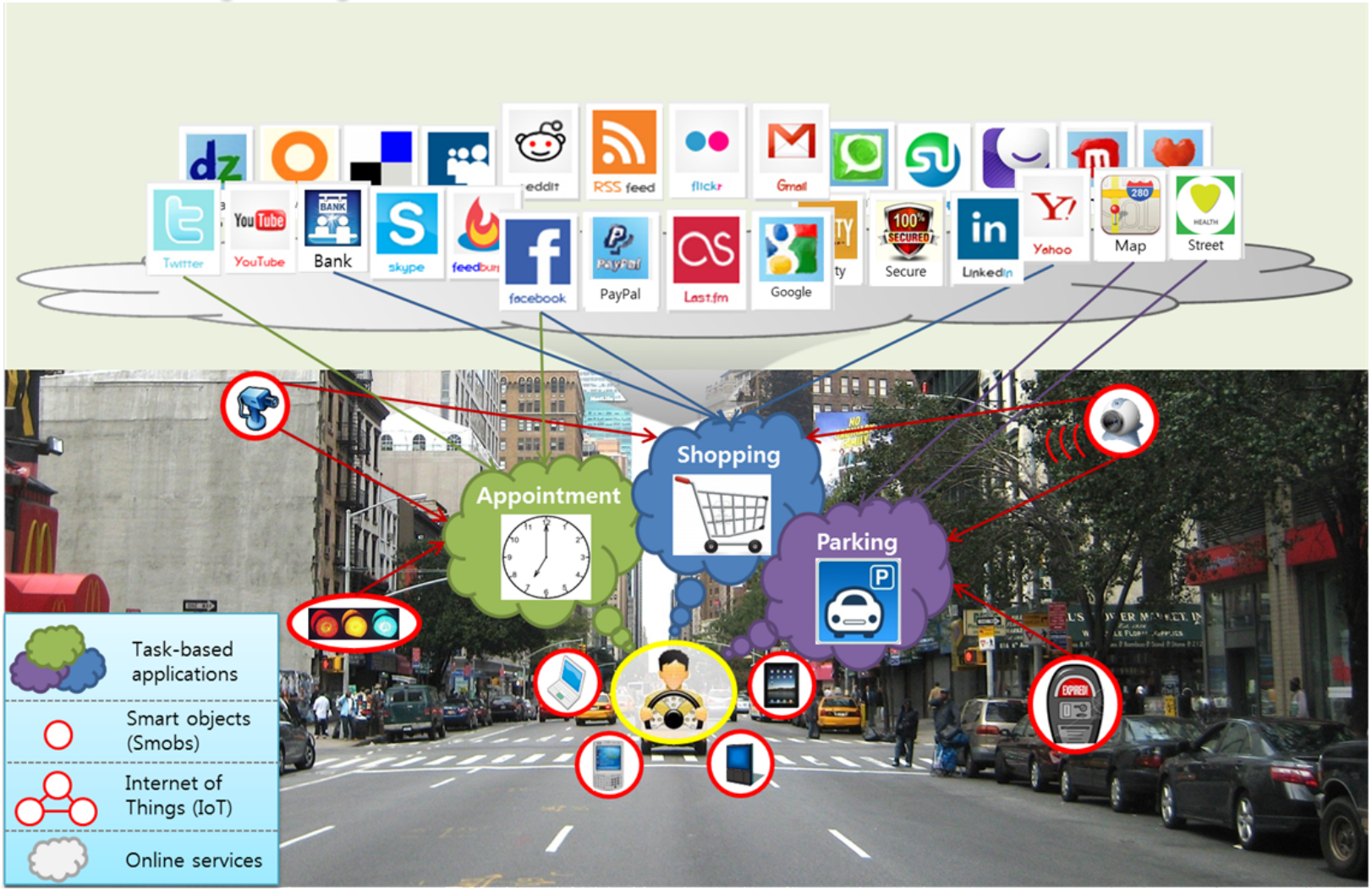
- Retail future vision

  http://www.youtube.com/watch?v=rUSDWTiTs7o

- HP Cooltown

  https://www.youtube.com/watch?v=I5hzIDNDK1M

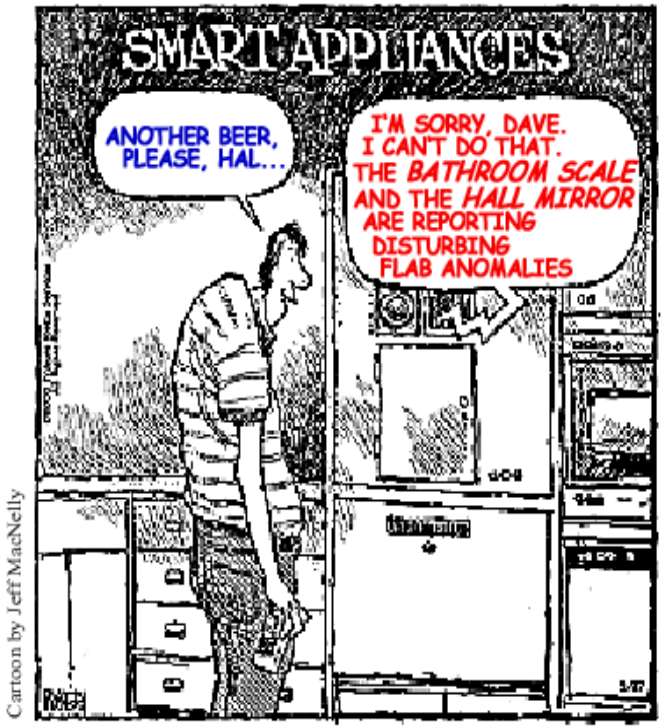
Technology into the Fabric of Everyday Life

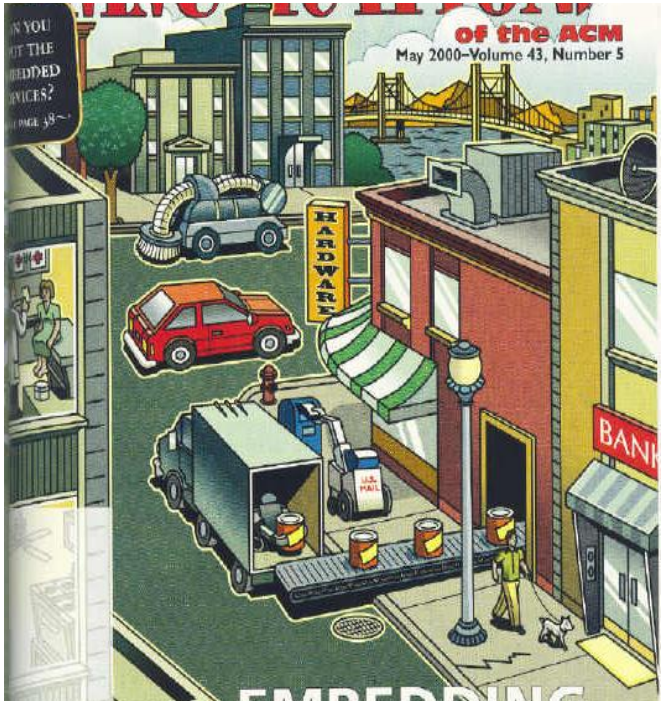


Source: own elaboration in KAIST

What is Ubiquitous Computing?

- Ubiquitous Computing Vision
  - "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" – *Mark Weiser*

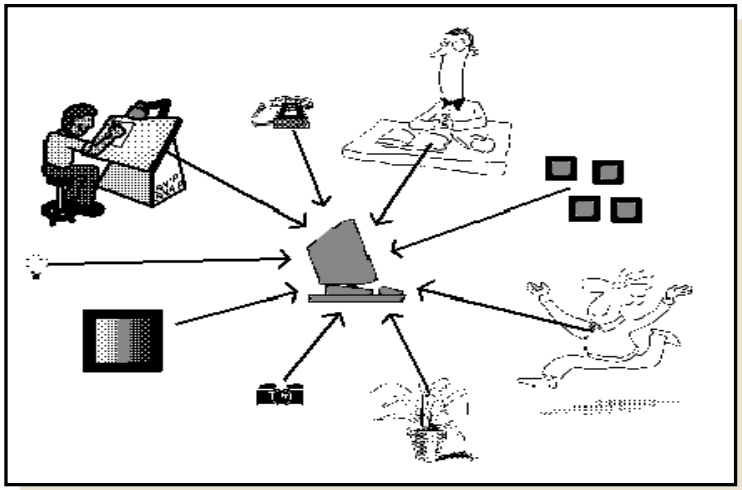




What is Ubiquitous Computing? (2)

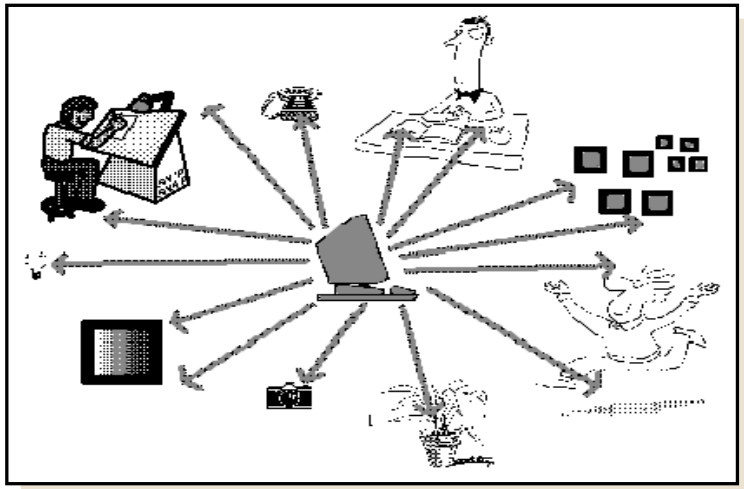
- Paradigm Shift

Virtual Reality



Physical space -> Virtual Space

Embodied Reality (ubiquitous computing)



Virtual space -> Physical space

Slide by Dongman Lee, KAIST

Ubicomp Definitions

- Definitions
  - Provides user distraction free environments – *CMU*
    - "The most precious resource in a computer system is no longer its processor, memory, disk or network but user attention" (project Aura)
  - Provides users to access information easily without considering about location, time, device, and network – *IBM*
  - Computations enter the human world, handling our goals and needs and helping us to do more while doing less – *Oxygen*
    - Boost our productivity
    - Help us automate repetitive human tasks, control a wealth of physical devices, find the information we need, and enable us to work together with other people through space and time

Key Features for Ubicomp

- Invisibility
  - Ideal – complete disappearance of ubiquitous computing technology from a user's consciousness (video brain-to-brain)
  - Practical – reasonable approximation to this ideal – minimal user distraction
  - Not only hardware but also software
    - Hardware aspect (physically invisible)
      - Tangible interfaces, smart appliances, etc.
    - Software aspect (logically invisible)
      - Not intrude to users, self-configure, self-adaptive system
- Effective use of services (information)
  - Personalized/community-aware information service
    - Public display, priority in a party (policy, privacy, publicness, utility function, democracy)
- Harmonized share of resources with other users
  - Off-loading example

Key Enablers

- Ubiquitous/Pervasive computing is a fusion of:
  - Tangible computing
  - Context-aware computing
  - Location-aware computing
  - Social computing
  - Affective computing
  - Service oriented computing

Slide by Dongman Lee, KAIST

Context-aware Computing

- Context
  - "Any information that can be used to characterize the situation of an entity" [Dey]
- Context Awareness
  - Capacity to extract, interpret, and use context information to deliver services
  - … to reconfigure service composites
- Context-aware fleet management system
  - Leverage context information to enhance a decision-making process

Context

- Definition of Context
  - Enumeration-based
    - Various categories [Chen and Kotz's 00]
      - Computing context: network connectivity, BW, local resources….
      - User context: profiles, location, people in the vicinity of the user…
      - Physical context: lighting and noise levels, traffic condition, temperature.
      - Temporal context: time of day, week, month, season of the year..
      - Context history: recording of computing, user,.. Previous context..
    - Five W's [Abowd and Mynatt 00]
      - Who: social context, user id, user context
      - What: functional context, what tasks the user is performing
      - Where: location context, user/system's location; *most prolifically used*
      - When: temporal context
      - Why: motivating context, why the user is performing a certain task; *most difficult – meaning!*

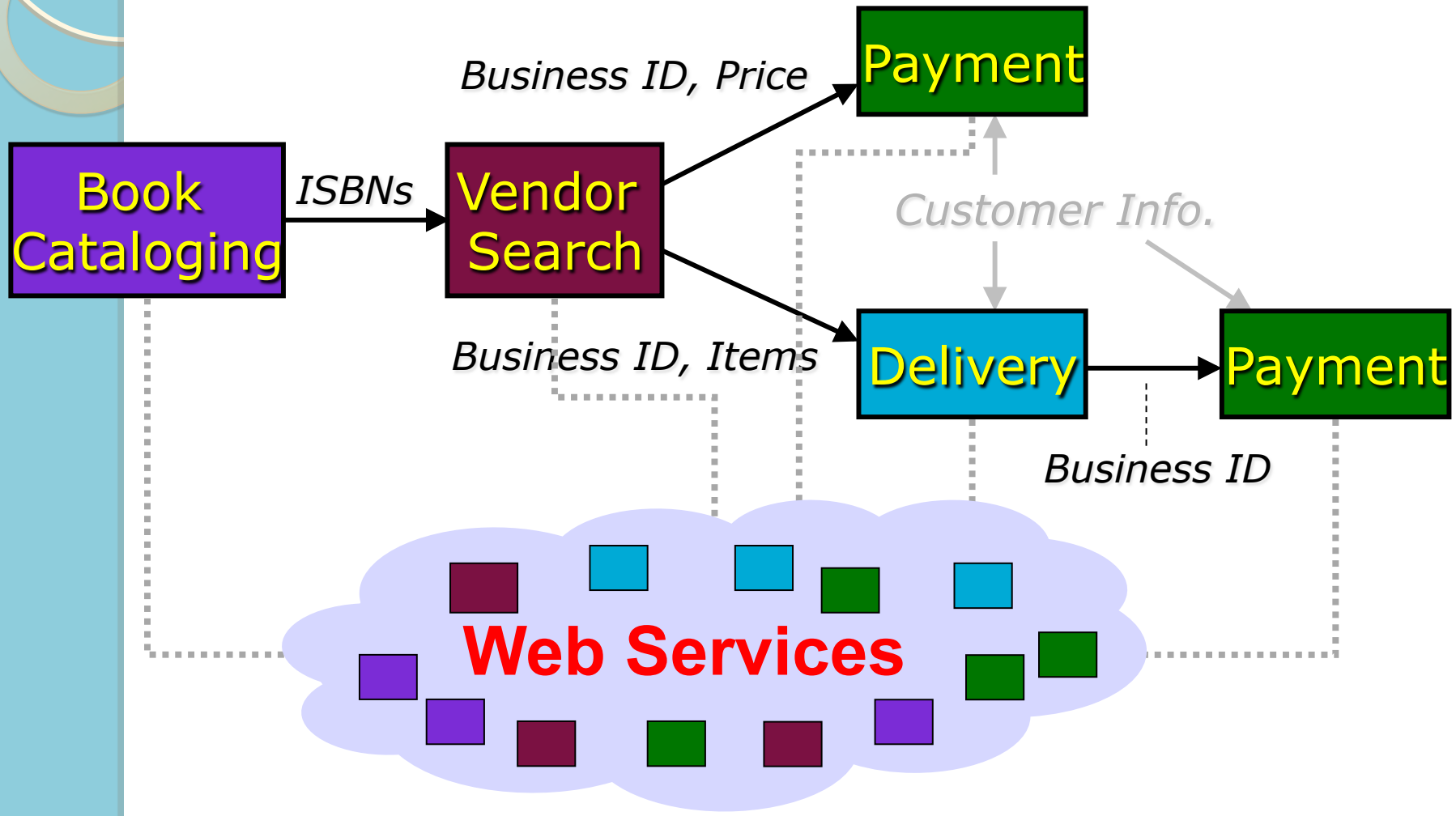
Context (2)

- + User's emotional state (emotional context), environment such as temperature, illumination level (environmental context) → see urban ontology…
- Further into
  - Low level context: sensed information, location…
  - High level context: amalgamation of low level context + AI or machine vision to infer situations such as:
    - *Is in meeting, waiting at the airport, entering the room, waking up, brushing teeth,…*

Activity Recognition

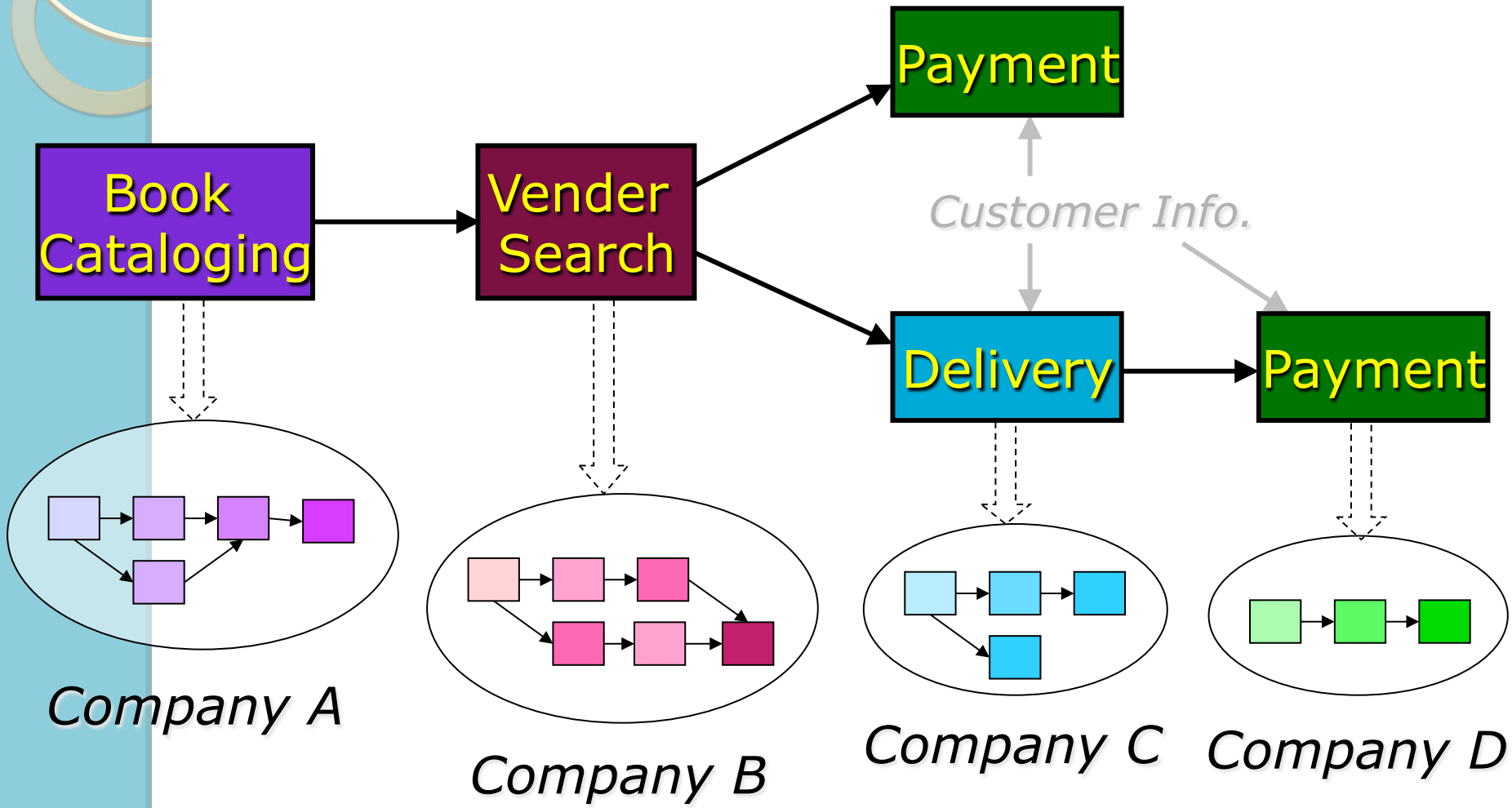
Mobile eye trackers, EEG, ECG, blood pressure, etc.

Book Purchasing Process



(Courtesy of Ko, I-Y et al.)

Book Purchasing Process



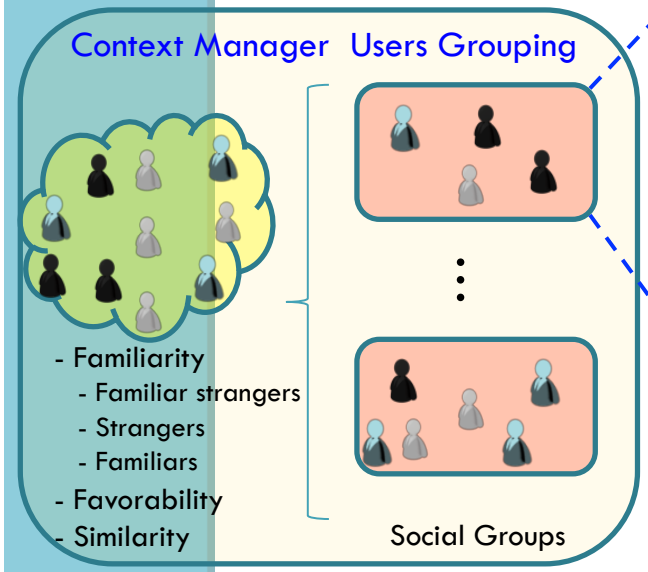
(Courtesy of Ko, I-Y et al.)

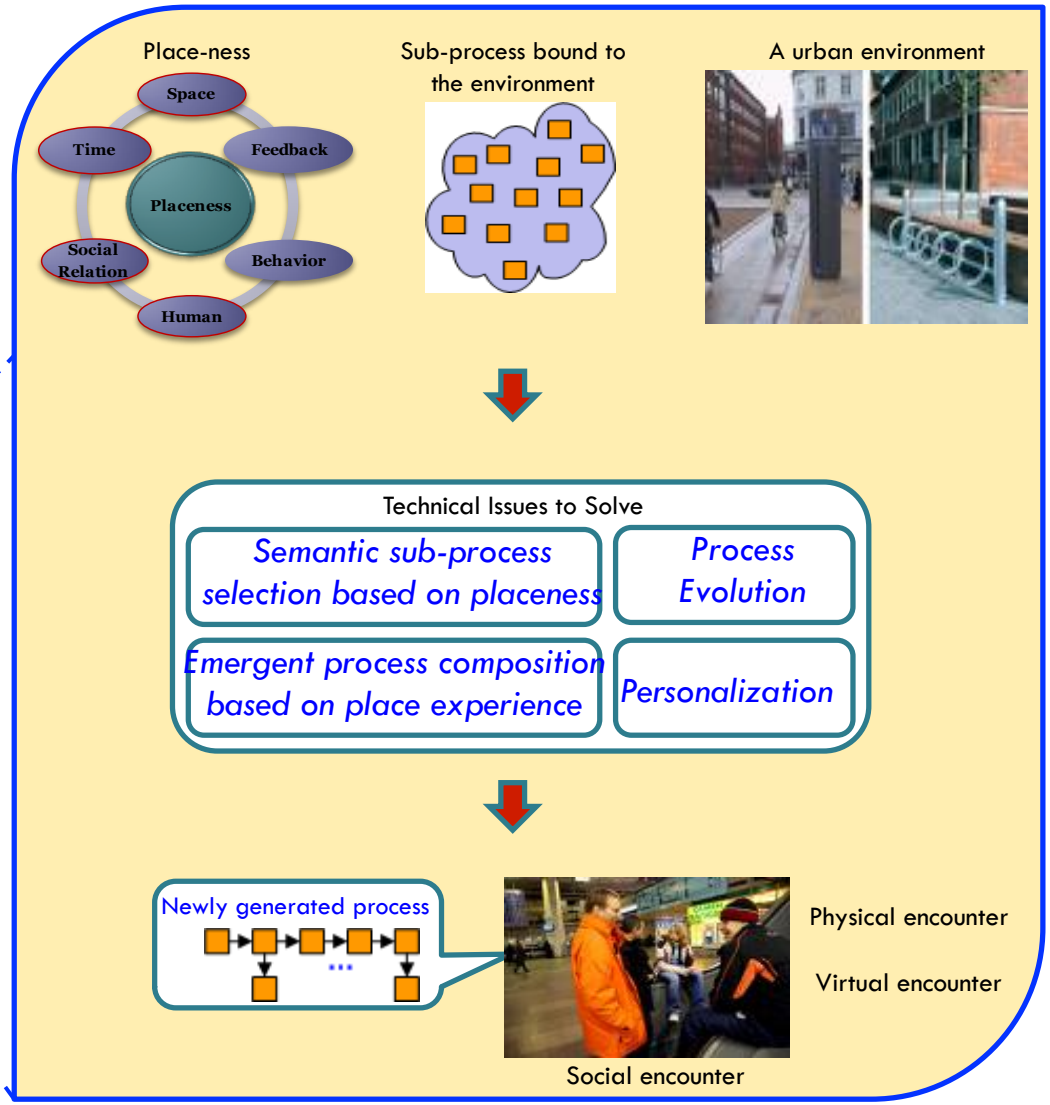
WHAT IS GOING ON IN THE ACADEMIA?

Spontaneous Social Computing

Spontaneous Service Provisioning for Social Groups

- Spontaneity:
  - Supporting spontaneous interactions among users by coordinating available services during runtime, without having a previous definition of applications into templates or other predefined descriptions.



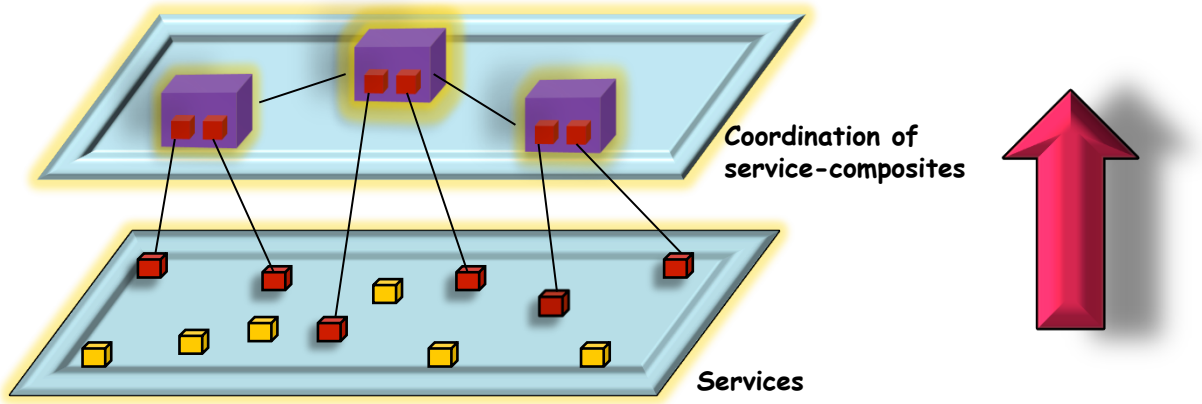


Source: own elaboration

Direction of Approach

Opportunistic Service Composition

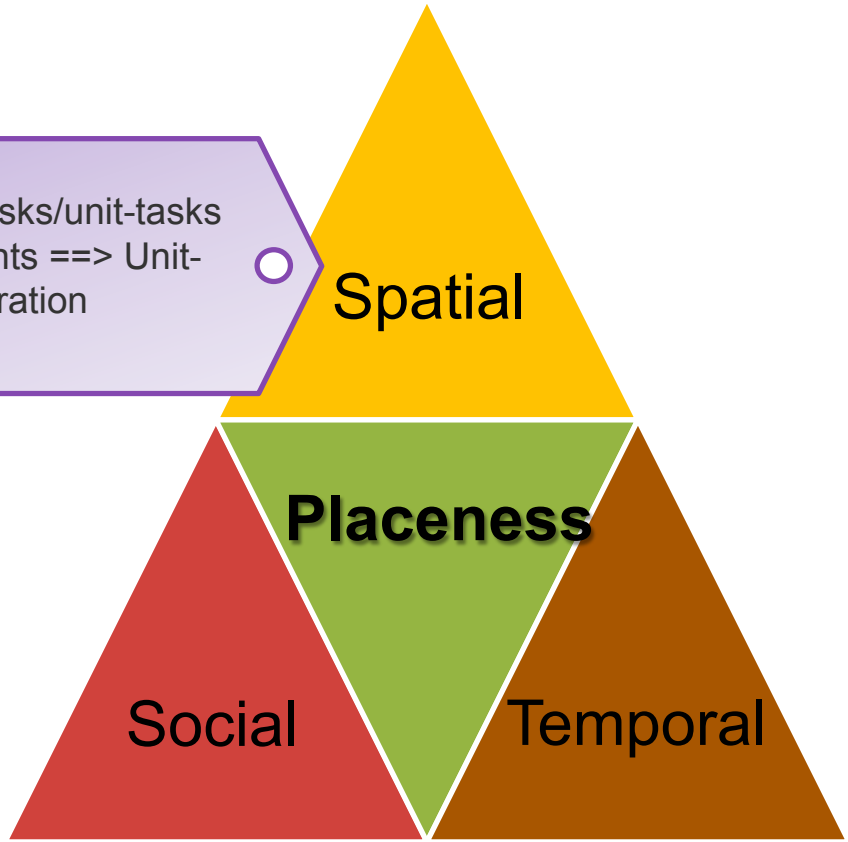
- Major affecting factors
  - Social encountering behavior
  - Situational user cognitive resources - attention demanding of mobility tasks
- Other supporting factors
  - Place roles and potentials
  - Situation and place publicness level
  - Situation formality level
  - Temporal rhythms – temporal patterns of place use
  - Cyber and physical social relationships
  - Physical characteristics of places – environmental constraints
  - Availability of physical services - embedded open-ended services



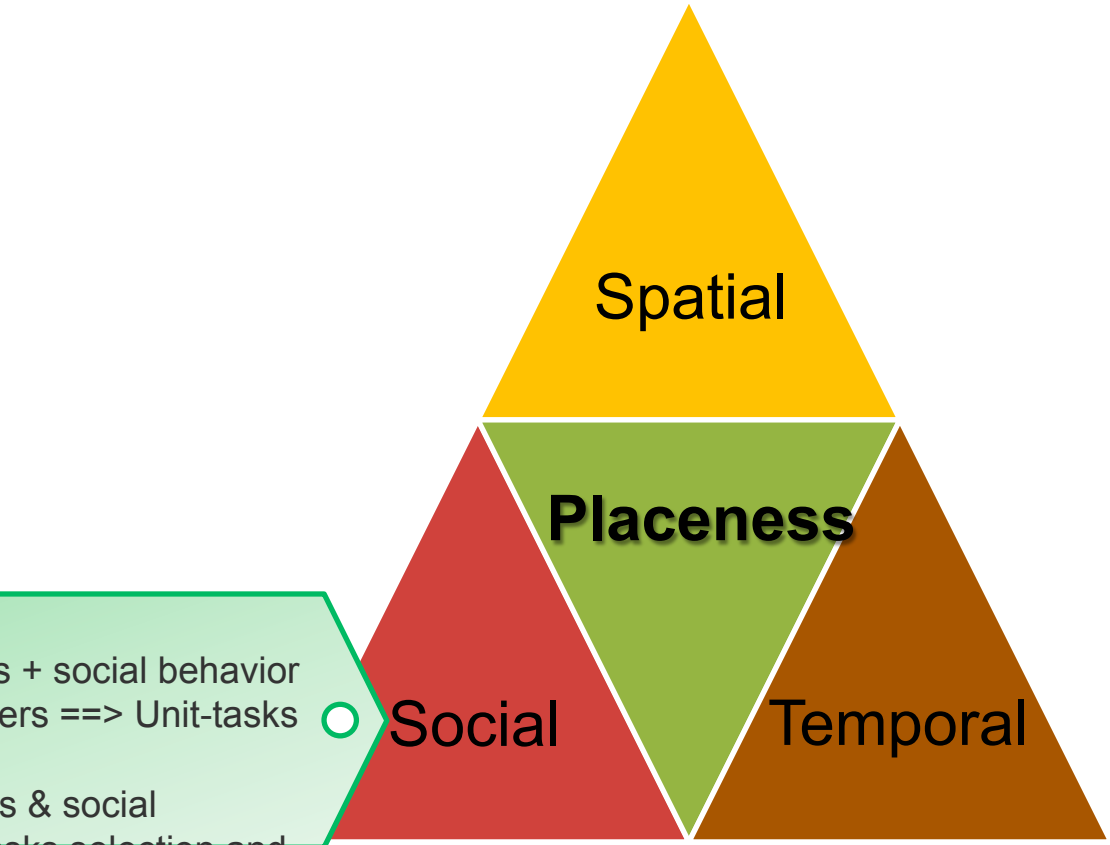
Social, Spatial, and Temporal Aspects

1. Spatial Aspect
- Place potentials ==> Tasks/unit-tasks
- Environmental constraints ==> Unit-tasks selection and integration

[Carmona et al., 2003]
[Paay et al., 2009]
[Knox & Ozolins, 2000]
[McCullough, 2001]



Social, Spatial, and Temporal Aspects



2. Social Aspect
-Social relationships + social behavior ==> Social encounters ==> Unit-tasks selection.
- Level of publicness & social formality==> Unit-tasks selection and integration.

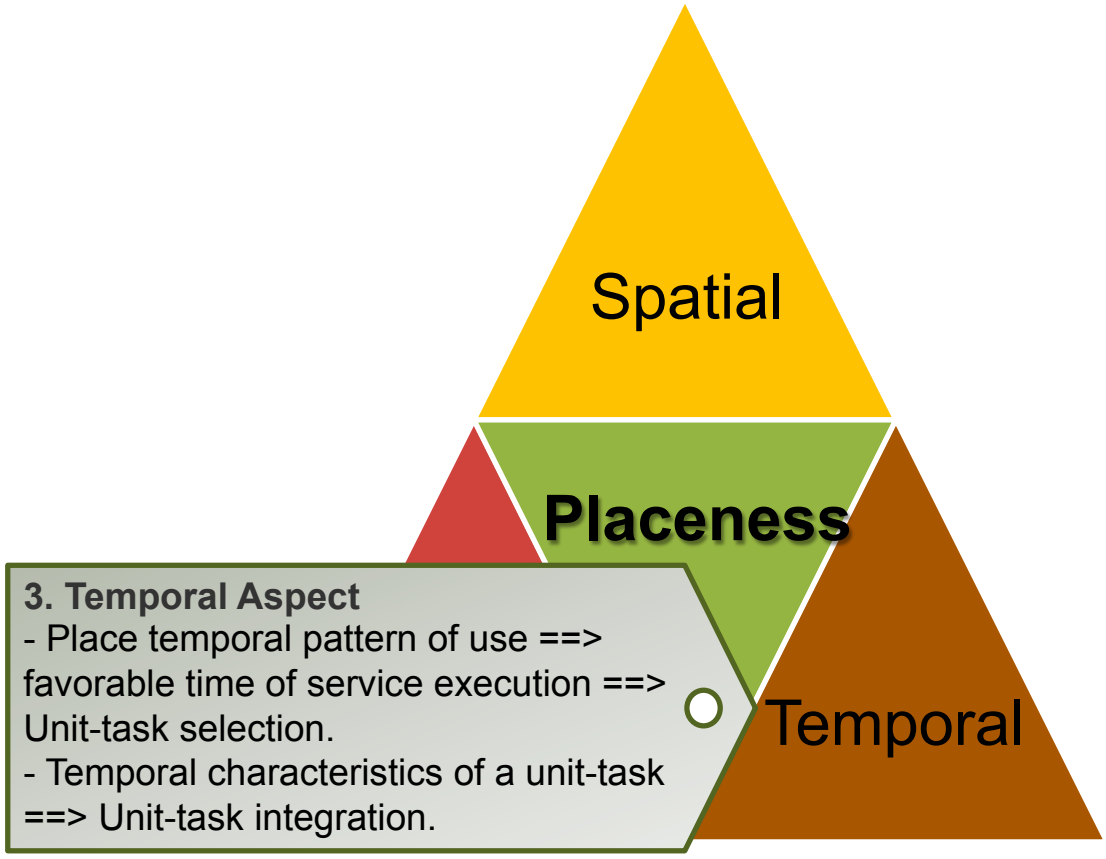
[Barnerjee, 2001]
[Oldenburg, 1999]
[Carmona et al., 2003]
[Paulos & Goodman, 2004]

Types of Social Encounters

- Spontaneity
  - Characterizing the social group as ad hoc (spontaneous), or pre-existent.
    - That is, if the group was first formed, or already there were antecedents about its identification and support.
- Social encounter type (Paulos and Goodman, 2004)

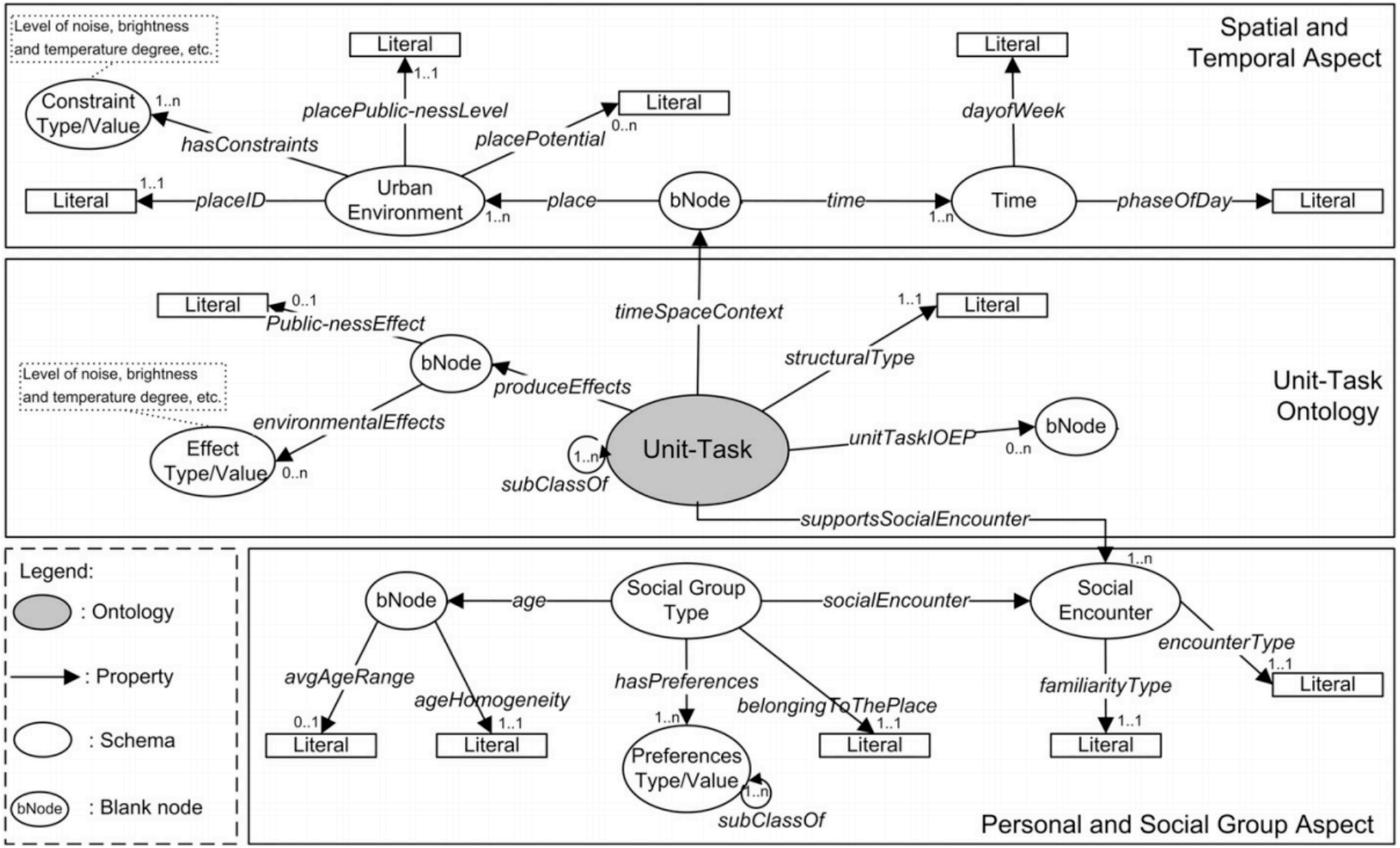
	Physical encounter (known identities)	Virtual encounter (known identities)	Virtual encounter (anonymous users)
Familiars			
Familiar strangers	 (Different UrbComp)	 (Different UrbComp)	 (Same UrbComp)
Strangers			

Social, Spatial, and Temporal Aspects



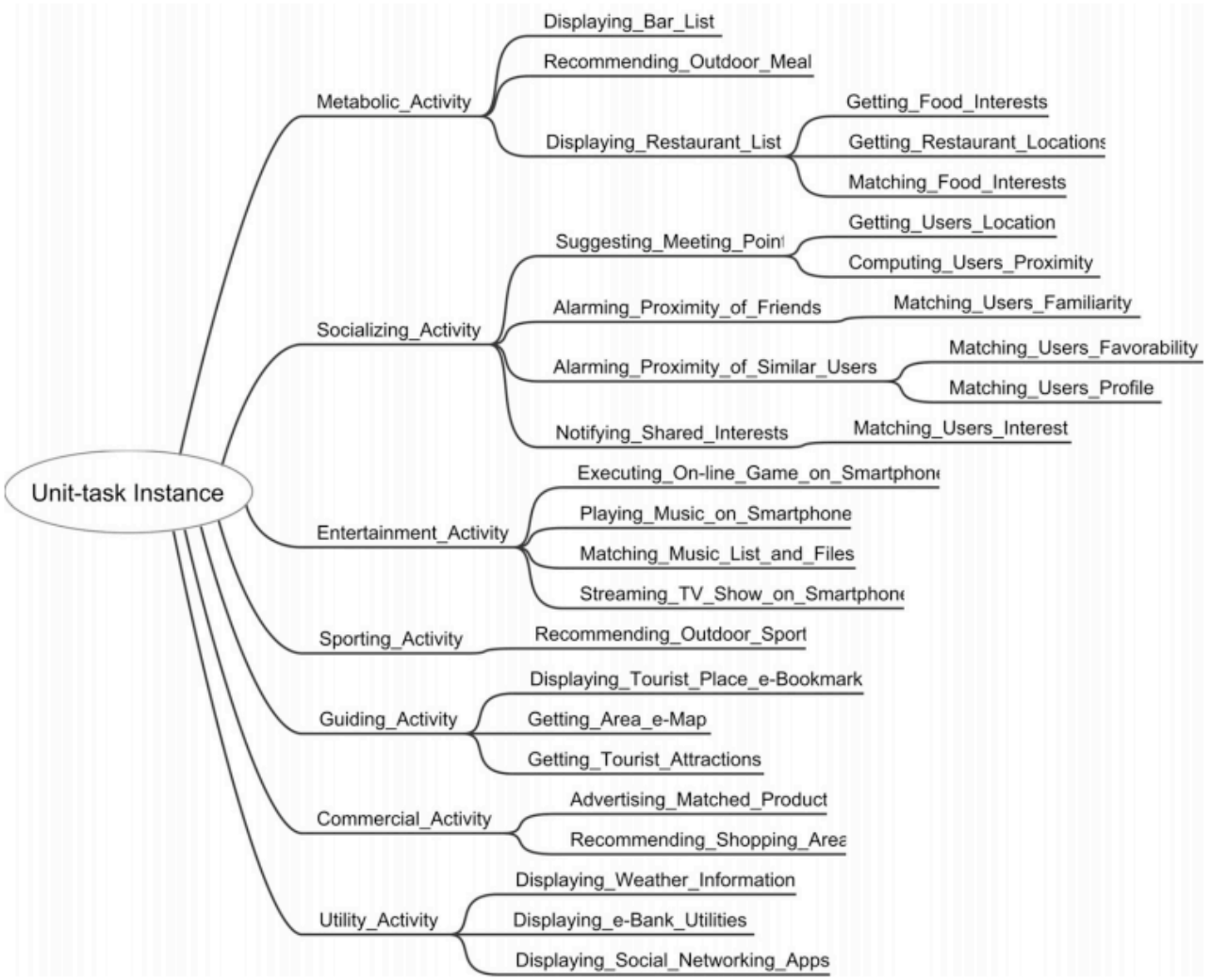
[Kostakos et al., 2009]
[O'Neill et al., 2006]
[Partridge et al., 2008]
[Ardagna & Pernici, 2007]

Semantic Description of Context Information



Source: own elaboration

Applications

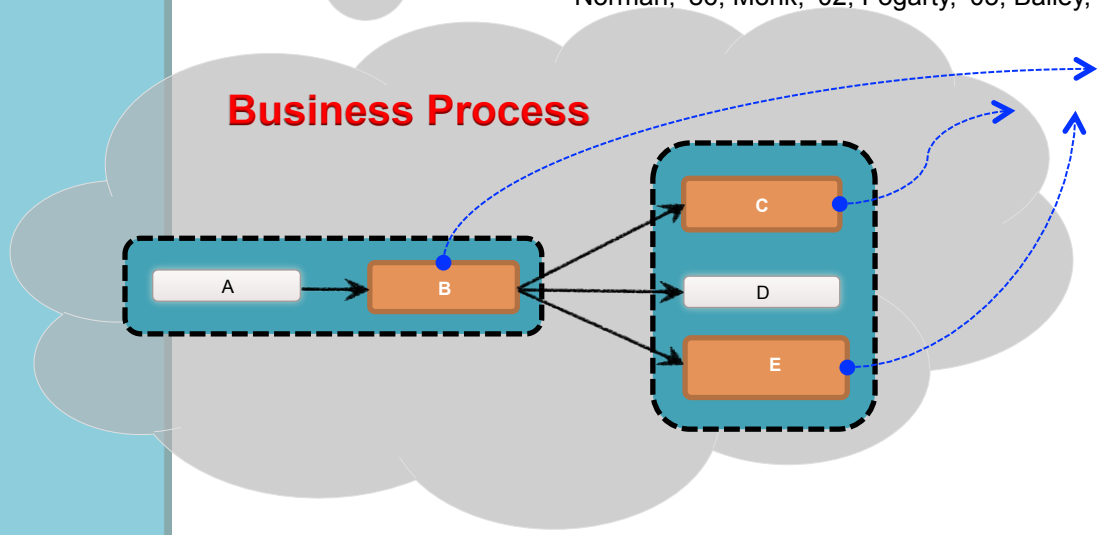


Cognitive Resources as Context

Physical Activities

Human physical activities override HCI tasks of HCI services [Oulasvirta, '05]

- Cognitive resources demanded by HCI tasks hinders the execution of physical activities [Oulasvirta, '05]
- Interruption of the user's ongoing activity [Miyata & Norman, '86; Monk, '02; Fogarty, '05; Bailey, '06]

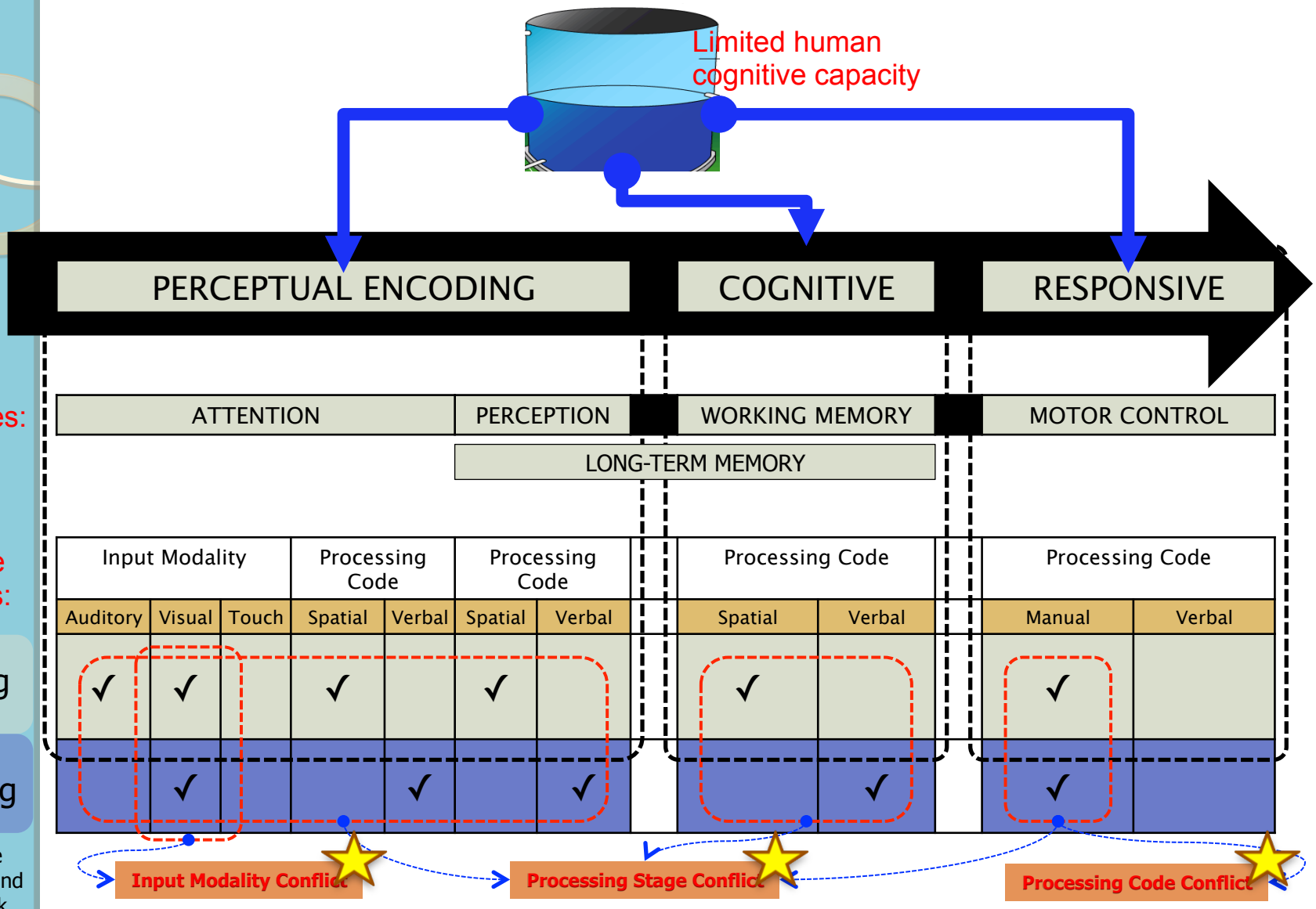


HCI Applications

HCI Tasks

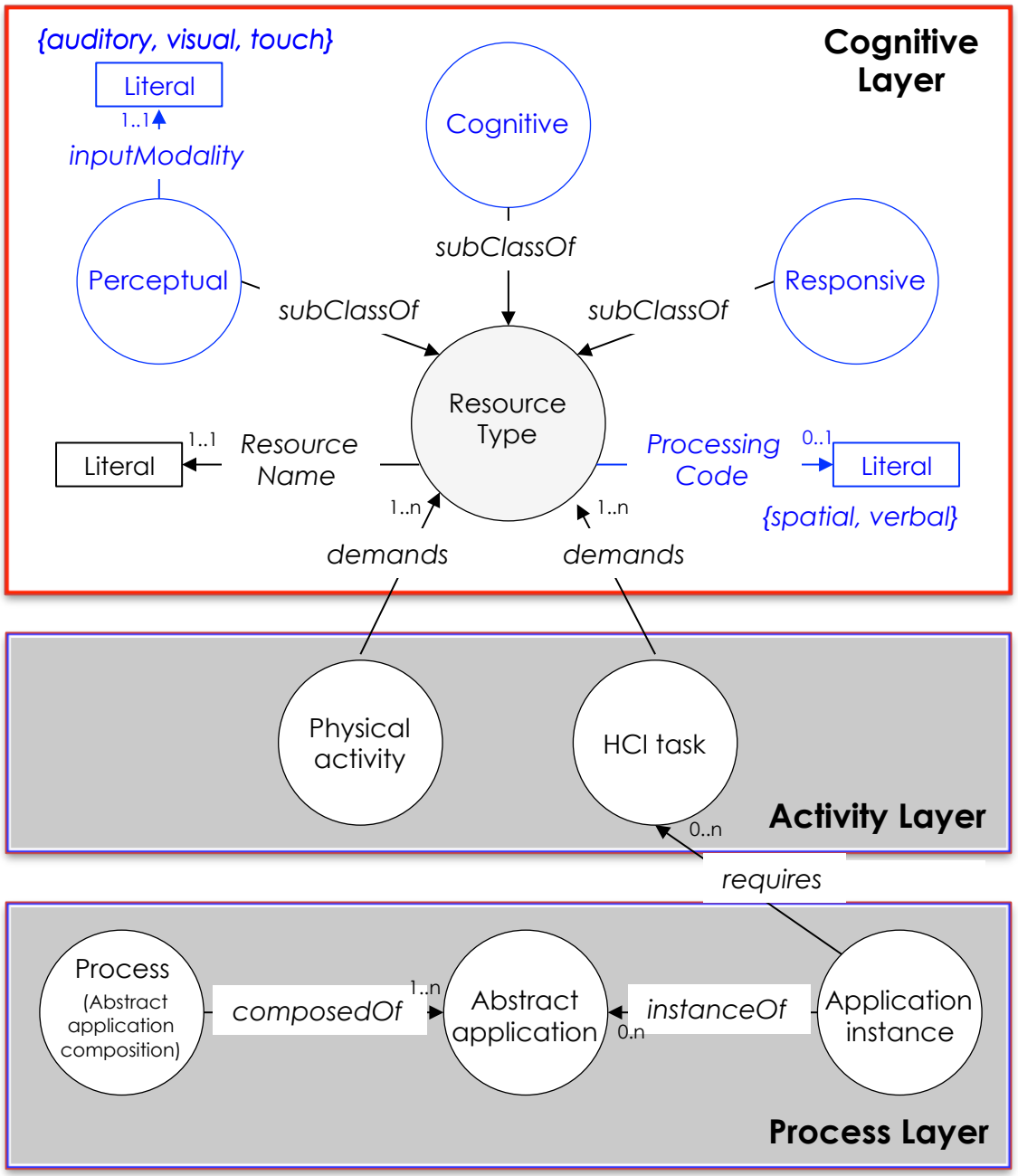
- Pushing Buttons
- Waiting for loading
- Reading information
- Searching from display
- Sensing vibration
- Thinking
- Etc.

The Human Processing System and Multiple Resource Competition



Adapted from [Wickens, '97]

Cognitive Resource Aware Activity & Application Description Model

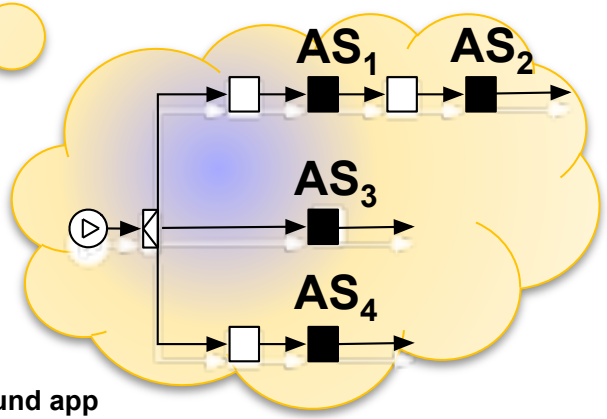


New Definitions in the Service Computing Domain

On-going activity

Services concurrency: a collection of abstract applications from different branches of a parallel construct, time-shared in an estimated time-window.

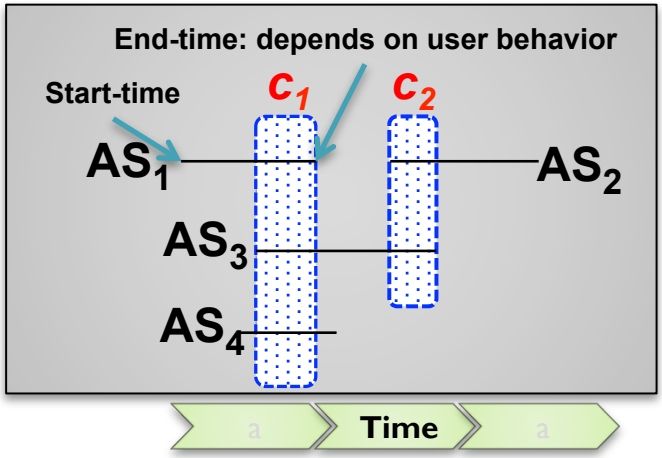
Abstract Application Composition

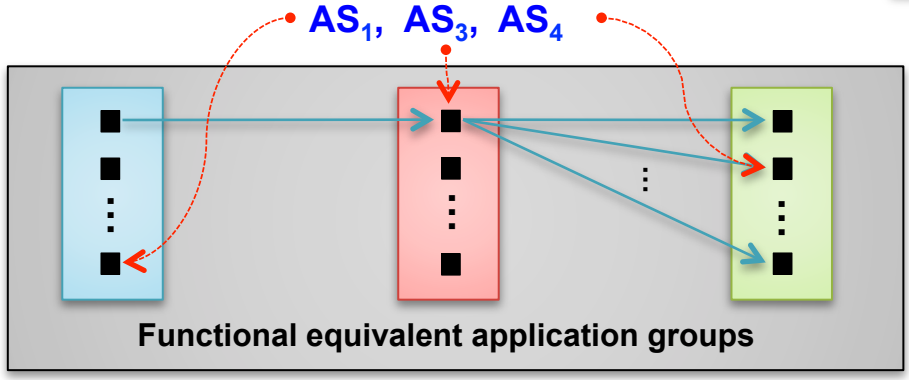


Background app

HCI abstract app

Concurrencies happen



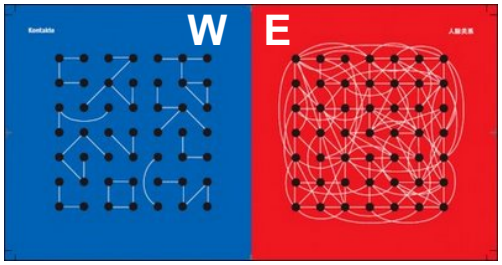


PRIVACY CONCERNS

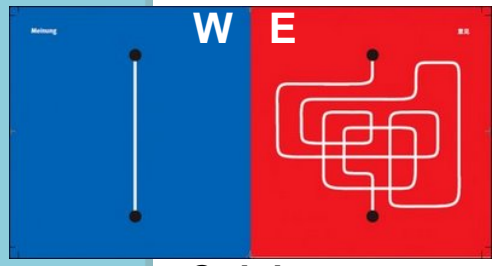
Who am I on twitter?

- What types of personal information do people share in online communities?
  - People have multi-faceted self identities

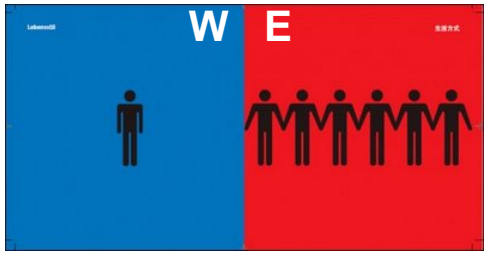
- Do Easterners and Westerners describe themselves differently due to their culture norms?
  - Western – Individualism
    - E.g., Europe, North America
  - Eastern – Collectivism
    - E.g., East Asia



Personal Relationship



Opinion



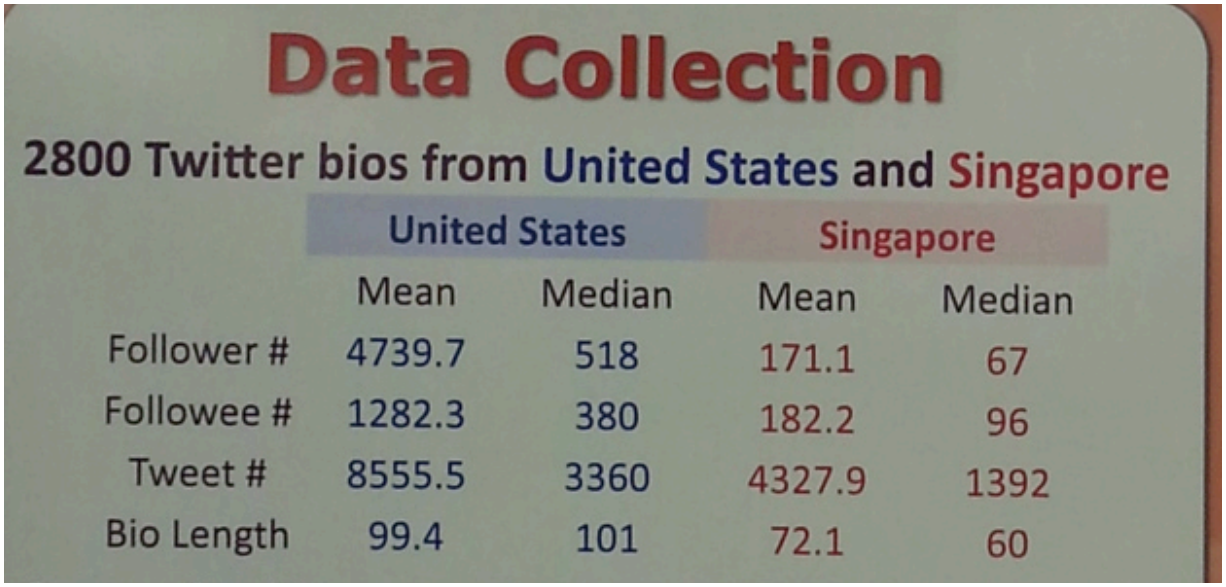
Lifestyle

Culture Norms

	Western	Eastern
Self-expressiveness	Express oneself in a direct communication style	Restrain self, fit-in & maintain harmony with social context
Privacy Concern	Value privacy, protect private life from intrusion of others	More acceptable to others' intrusion into their private life

- Culture norms in self-expressiveness and privacy concerns may influence users' information disclosure behavior in opposite directions

Data Collection



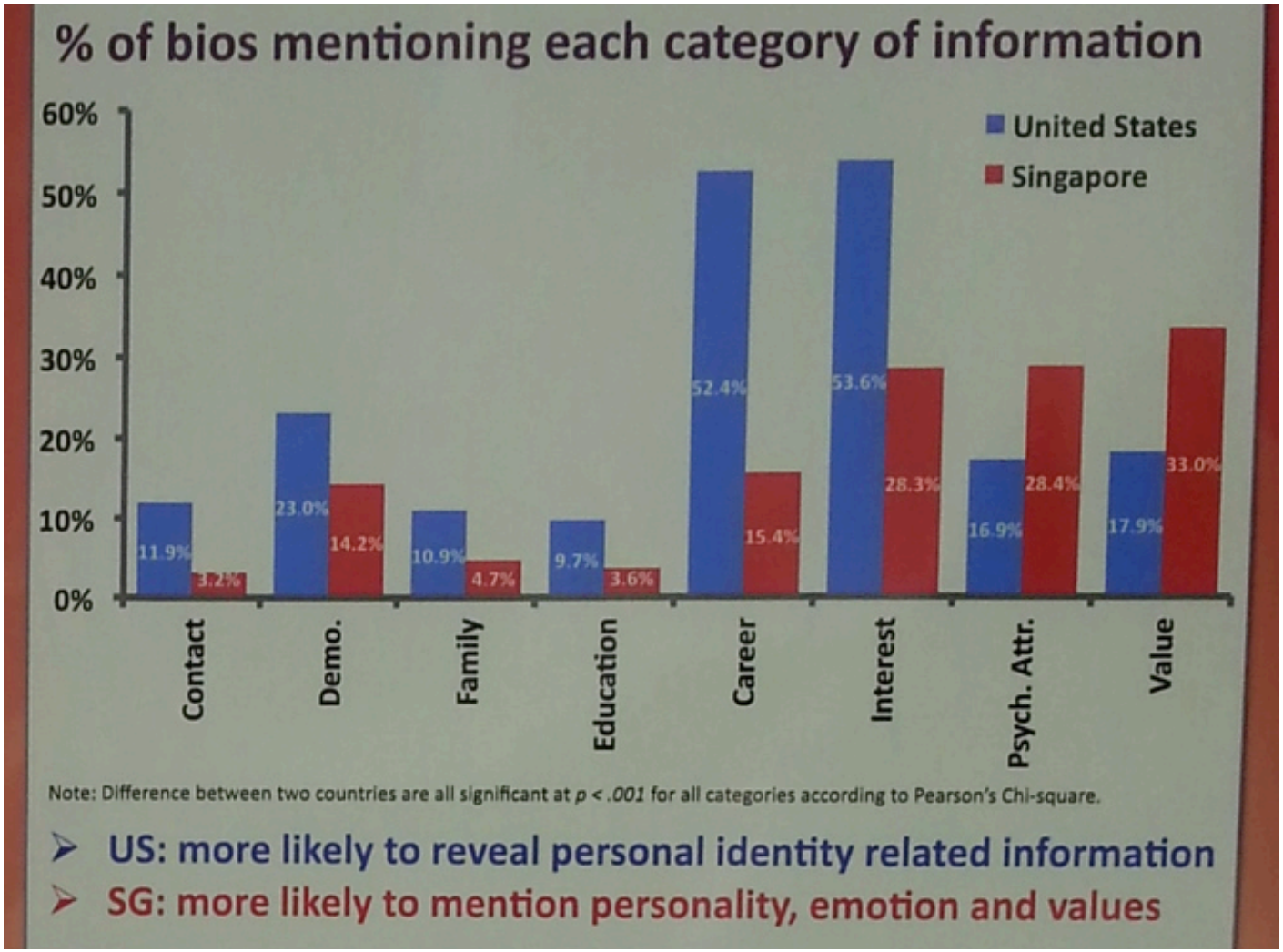
Source: Wei Dong et al., WWW 2014

Categorization of Bio Content

	Category	Description and Examples
Personal Identity Revealing	Contact Information	Email, Phone #, personal website/blog url, IM or other SNS account, mailing address
	Demographic Information	Age, gender, ethnicity, nationality, location, language, physical appearance, etc.
	Family/romantic relations	Father, mother, daughter, son, siblings, grandparents, boyfriend, girlfriend, etc.
	Educational background	School/college/university attended, degree, major, etc.
	Career	Workplace, occupation, profession, career-related skills, etc.
Other	Personal Interest	Preferences, interests, hobbies or celebrities that one likes, etc.
	Psychological Attributes	Personality (e.g., easy-going, friendly), emotional status (e.g., happy, sad), etc.
	Values and attitudes	Religious or political views, values, attitude, proverbs that convey similar information

Source: Wei Dong et al., WWW 2014

Results



Source: Wei Dong et al., WWW 2014

Conclusion

Twitter users in the US and in Singapore disclose different types of personal information in bios

- US: content of bios more likely to reveal true identity
- SG: it is difficult to use the personal traits mentioned in bios to track the user down in real life

Why do personal information disclosure behavior differ in different regions of the world?

- Different goals of using online community platforms?
- Different levels of trust towards friends vs. strangers?

Source: Wei Dong et al., WWW 2014

Questions?