

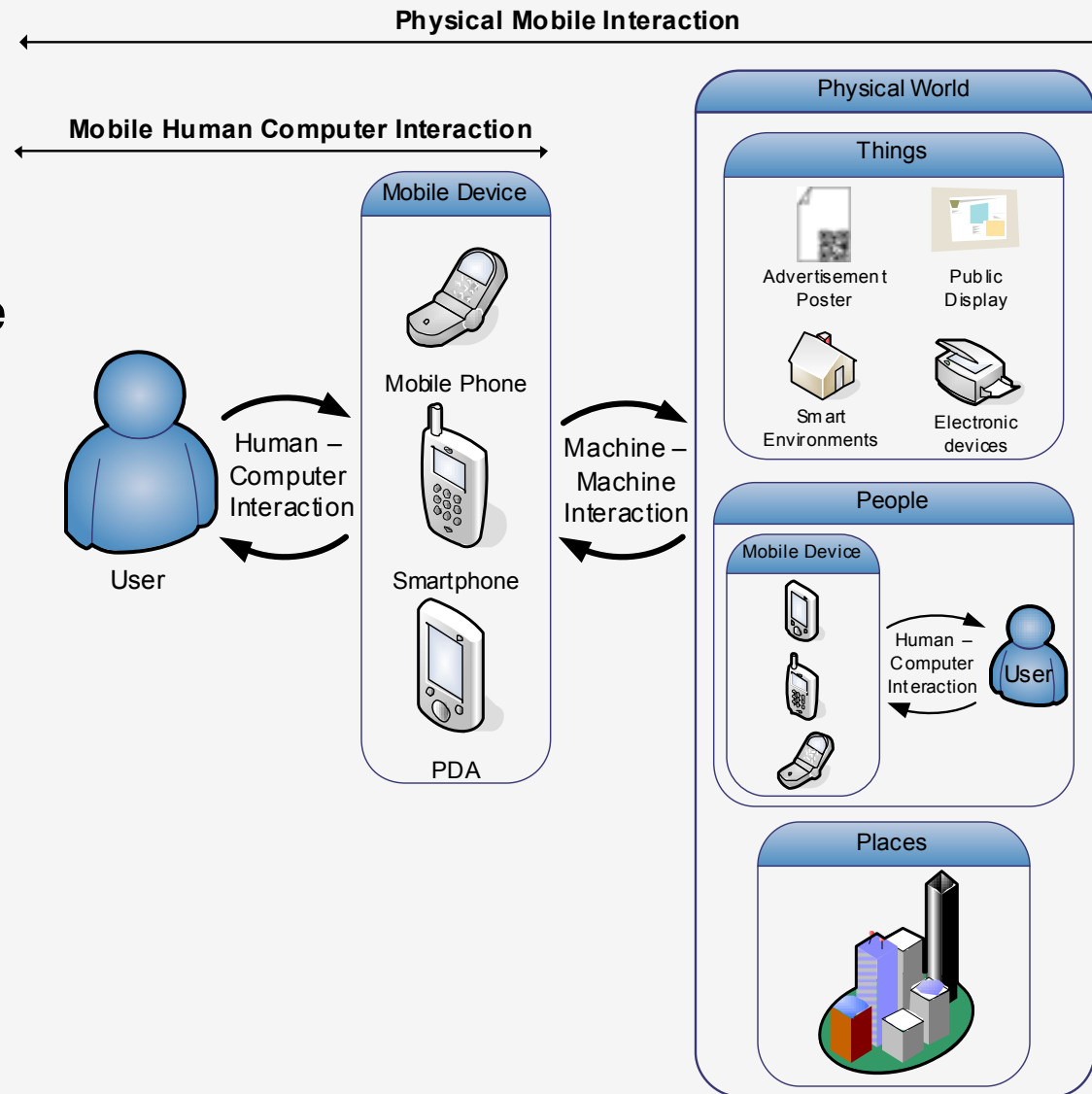
- Physical Mobile Interactions - Mobile Devices as Pervasive Mediators for Interactions with the Real World

Enrico Rukzio

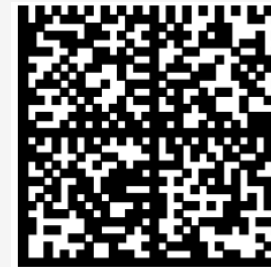
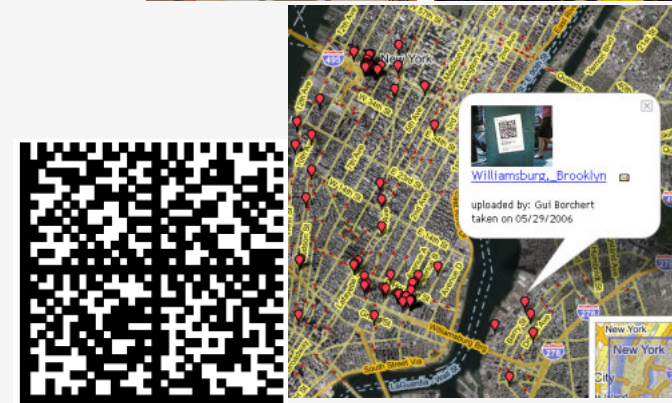
University of Munich (Germany), Lancaster University (UK)

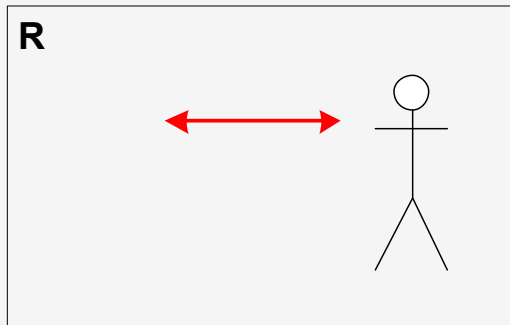


- Physical Mobile Interactions
 - Mobile interactions in which the user interacts with the physical world through a mobile device which interacts with smart objects.
- Application areas
 - Active posters and advertising
 - Tourist and museum guides
 - Electronic key and ticketing
 - Payment
 - Peer-to-peer sharing
 - Remote control and interaction with displays
 - Field force

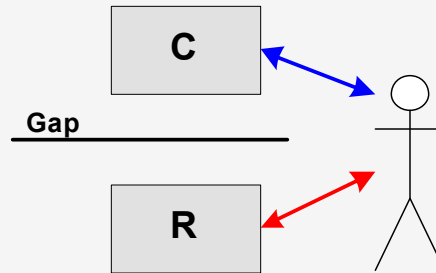


- NTT DoCoMo i-mode Felica
 - Mobile phones support Near Field Communication
 - Services: mobile wallet, boarding pass, electronic key
 - 15 million devices with i-mode Felica expected in Japan by end of 2006 [Boyd 2005]
- Semapedia.org
 - Semacode represents a link to a Wikipedia article
 - Taking a picture of the marker using the built-in camera of the mobile device
- QR Code
 - 30 million mobile phones with a QR Code reader in Japan [Fowler 2005]
 - Magazine, newspapers, house walls (up to 10 x 10 meter)

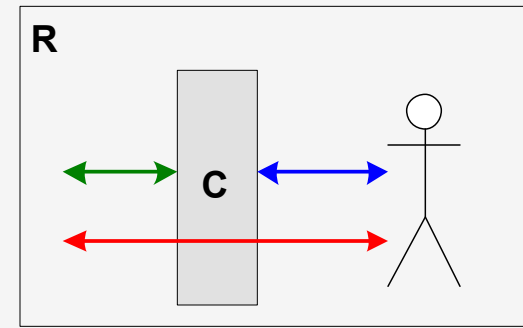




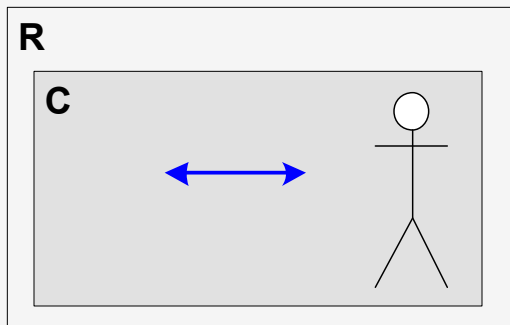
Before the computer



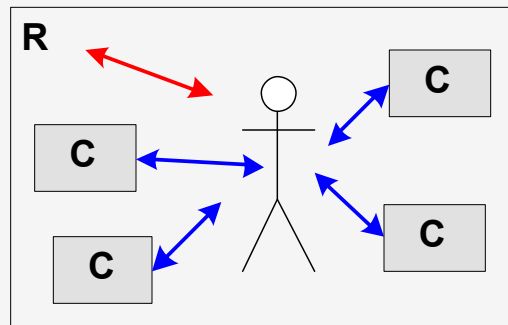
Usage of everyday computers
(laptop, mobile phone)



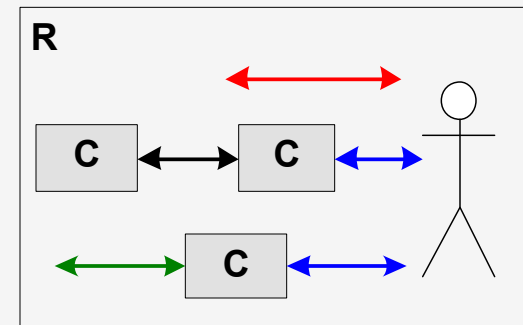
Augmented Reality
(Head Mounted Display)



Virtual Reality



Ubiquitous Computing
(Real World Computer)

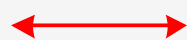


Physical Mobile Interactions

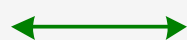
C – Computer
R – Real World



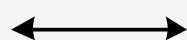
Human – Computer - Interaction



Human – Real World - Interaction



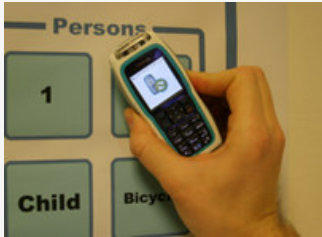


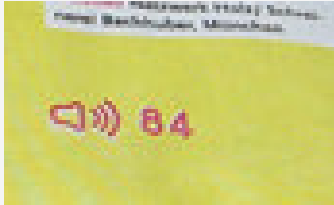

Computer - Real World - Interaction





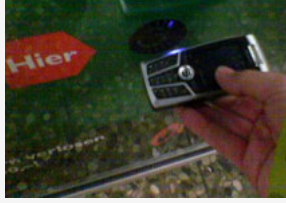



Computer – Computer - Interaction

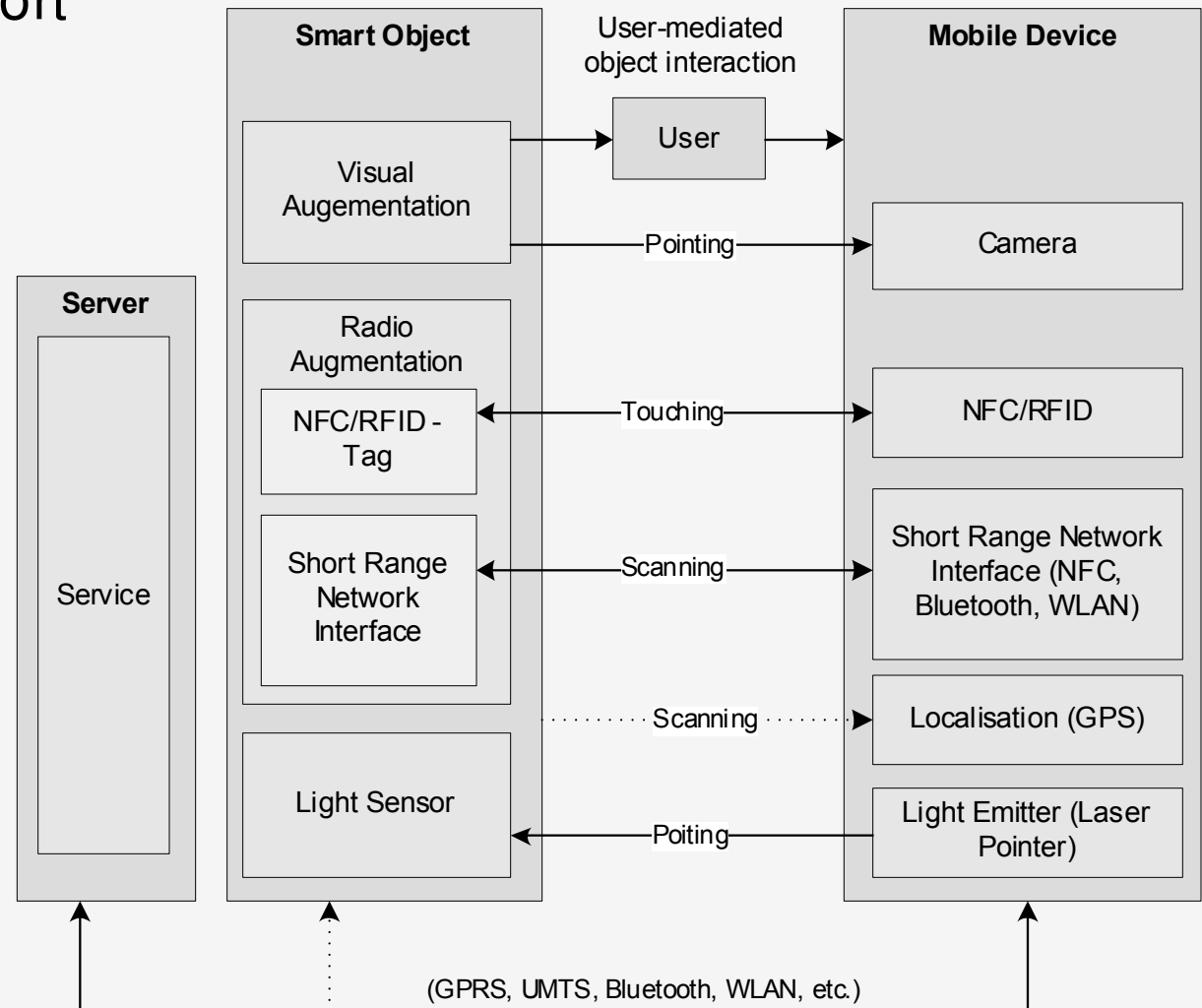
Based on [Rekimoto
and Nagao 1995]

- Which physical mobile interaction techniques exist?
- How can these interaction techniques be classified?
- Which implementations of the interaction techniques exist?
- What are the advantages and disadvantages of these interaction techniques?
- When is which interaction technique preferred by a user?
- Which software tools or frameworks can be used to support the development of applications that take physical mobile interactions into account (= physical mobile applications)?
- Which techniques, methods and tools can be used during the development of physical mobile applications?

Interaction technique	Touching	Pointing	Scanning	User-mediated object interaction	Indirect Remote Controls
Description	The user touches a smart object with a mobile device to establish a link.	The user points on a smart object with a mobile device to establish a link.	A link between mobile device and smart object is established because of their proximity.	The user types in information provided by the object to establish a link between them.	The user controls a remote display with a mobile device.
Illustration		 [Välkkynen et al. 2003]			
Real world aspects	Distance object - mobile device: 0... 10 cm, line of sight	Distance object - mobile device: 10 cm... 10 m, line of sight	Maximal distance object - mobile device: 100m	Line of sight and readable	Line of sight, often indoors
Device - Smart Object Interaction	Radio: RFID, NFC, proximity sensors	Visual: visual marker, light beam, IrDA	Location: Bluetooth, WLAN, GPS	No direct link	Communication: Bluetooth, GPRS, UMTS

Principle	Visual Marker	Image Recognition	Light beam	Unidentified	Infrared	Recognizing the mobile device
Illustration						
References	[Rekimoto and Nagao 1995]	[Föckler et al. 2005]	[Välkkynen et al. 2003]	[Schmidt et al. 2005]	[@Mobipoint]	[@BahnHandyTicket, Miyaoku et al. 2004]
Advantages	Markers are simple, inexpensive, disposable. No power supply.	Smart objects do not need to be augmented. No power supply.	Well known interaction (remote control).	No augmentation. No power supply.	IrDA is integrated in many mobile devices.	Handy possibility for identification (tickets, etc.).
Disadvantages	Visual obtrusiveness, limited storage capabilities.	Great demands on image recognition and data model.	Smart object must provide a feedback channel (RF, Bluetooth, etc.).	No computable information about the identity of the smart object.	Smart object must be enhanced by IrDA functionalities.	Code (e.g. paid ticket) can not be shown when mobile device is out of power.

- So far insufficient tool support
- Physical Mobile Interaction Framework (PMIF)
 - Easy development of physical mobile applications
 - Stream metaphor (Visual Marker: read only, NFC/RFID: read/write)
 - Various implementations of physical mobile interactions
- Java ME: MIDP 2.0 / CLDC 1.1



Interaction technique	Tested devices	Tested marker / technology
Touching (NFC)	Nokia 3220 + Nokia NFC shell	Mifare NFC tags (1 and 4 Kbyte)
Touching (RFID)	Nokia 6630 + IDBlue RFID pen	ISO 15693-3 tags (1 Kbyte)
Pointing (light beam)	Nokia N70/6630	light sensors (FW 300)
Pointing (visual marker)	Nokia 6600/6630/N70	Visual Codes, Semacode
Scanning (Bluetooth)	Nokia 6600/6630/6230i/N70	Brother MW-140BT mobile printer, GPS-devices, Dongle
Scanning (GPS)	Nokia 6600/6630 + Royaltek BT GPS x-mini or Blue GPS (RBT-3000)	N/A
User-mediated	Nokia 6600/6630/N90/N70	N/A (e.g. printed numbers)



- Mobile tourist guide: Mobile Petuelpark System (MOPS)
- Mobile museum guide: Mobile Point of Interest System (MOPS++)
- Mobile interaction with advertisement posters (Perci)
- Privacy sensitive ubiquitous computing (Discreet)
- Situated mobile commerce
- Mobile peer-to-peer file sharing
- Mobile learning
- Examples for every interaction technique (opening a hyperlink)



(MOPS)



(MOPS++)



Perci

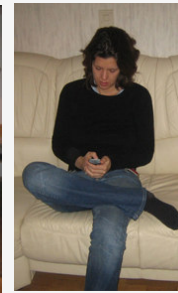
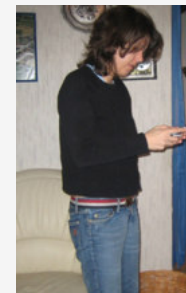


Discreet

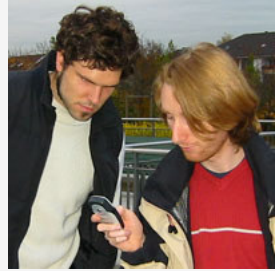
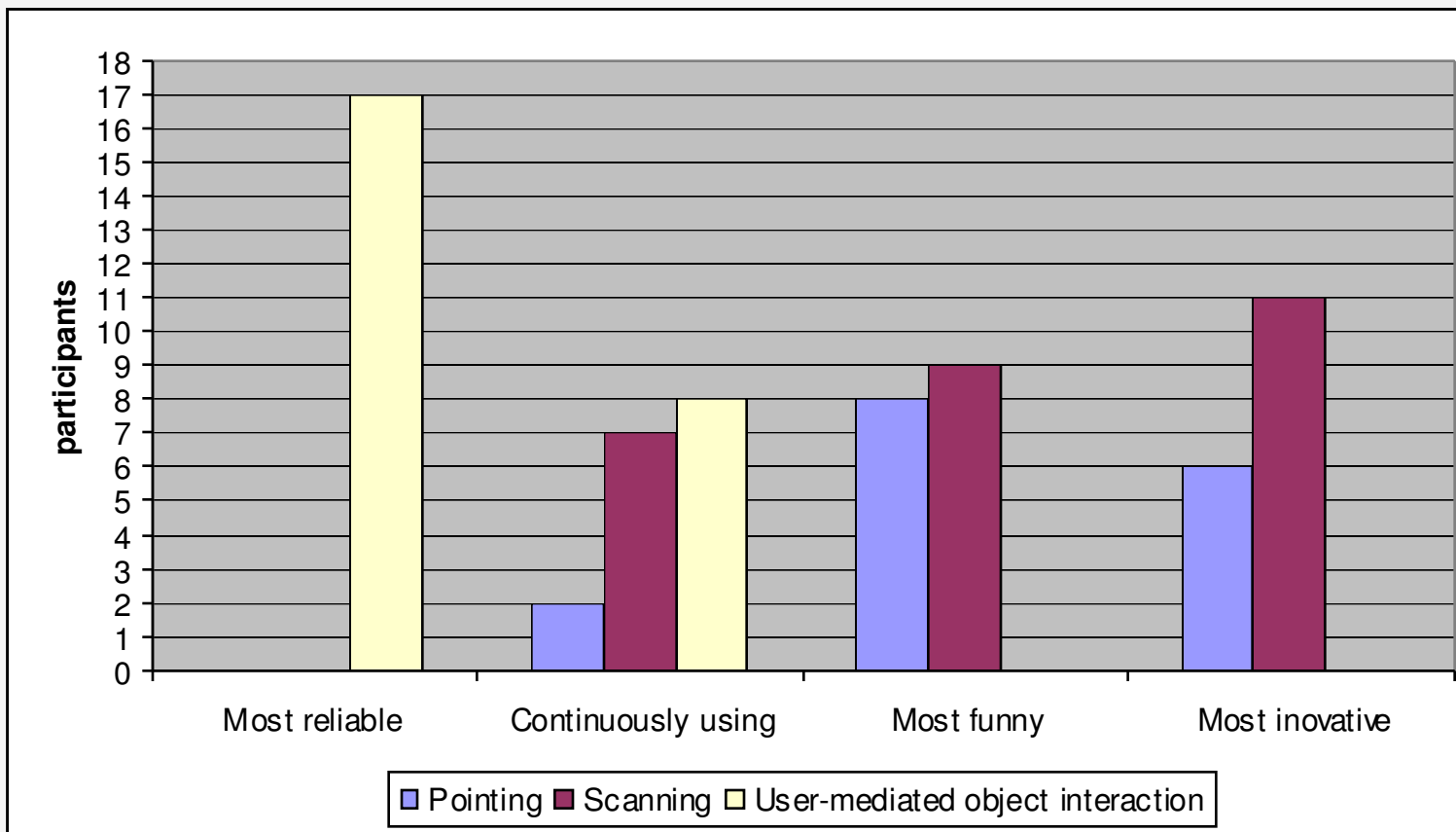
5 prototypes, 5 user studies and 4 tested interaction techniques

	Mobile interaction in smart environments	Mobile Tourist Guide (MOPS)	Mobile Museum Guide (MOPS++)	Mobile interaction with advertisement posters	Cinema scenario
Supported and tested physical mobile interaction technique					
Touching	NFC		RFID	NFC	NFC
Pointing	Laser pointer	Visual Marker	Visual Marker	Visual Marker	
Scanning	Bluetooth	GPS			
User-mediated object interaction		Number	Number	Labels	
User study					
Participants (average age)	20 (28)	17 (24)	8 (28)	17 (29)	20 (26)
Conducted in	03 / 2006	11 / 2005	05 / 2006	06 / 2006	11 / 2005

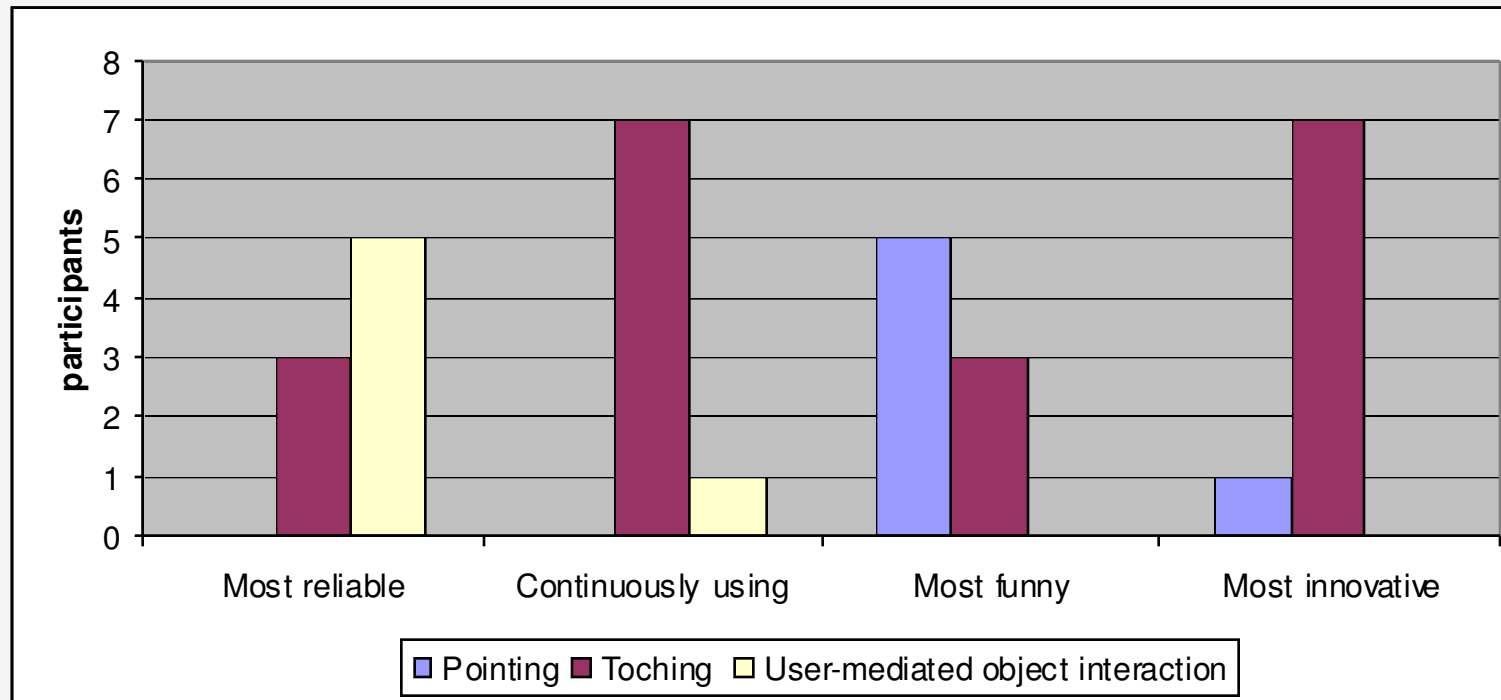
- Mobile interaction with objects in smart environments
 - Objects: CD player, radio, heating, laptop
 - Interaction techniques: touching (NFC), pointing (laser pointer) and scanning (Bluetooth)
 - Activities: standing, sitting, lying
- Findings
 - Users prefer a specific physical mobile interaction technique depending on location, activity and motivation (e.g. security, speed or simplicity).
 - The current location of the user is the most important criterion for the selection of a physical mobile interaction technique.
 - The user's motivation to make any physical effort is low.



- Mobile interaction with art objects in a park (Petuelpark)
 - Interaction techniques: pointing (visual marker), scanning (GPS) and user-mediated object interaction (number)



- Mobile interaction with exhibits in a simulated museum
 - Interaction techniques: pointing (visual marker), touching (RFID) and user-mediated object interaction (number)

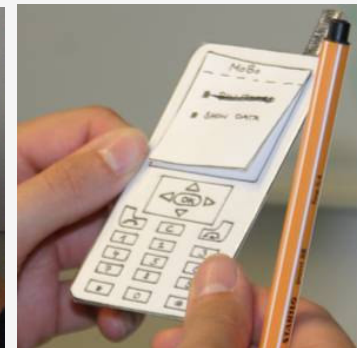
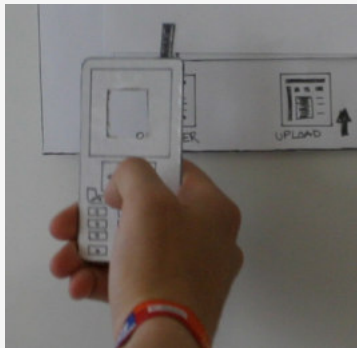


	Touching	Pointing	Scanning	User-mediated object interaction
Rating: good, average, bad				
Reliability, felt error resistance	Good	Good (laser pointer) - Bad (visual marker)	Average	Good (short identifier) - Average (long identifier)
Simplicity, intuitiveness	Good	Good (laser pointer) - Bad (visual marker)	Average (Bluetooth) - Good (GPS)	Good (short identifier) - Average (long identifier)
Performance, speed (within interaction distance)	Good	Average	Bad (Bluetooth) - Good (GPS)	Average (short identifier) - Bad (long identifier)
Rating: high, medium, low				
Physical effort	High	Medium	Low	Low
Cognitive load	Low	Medium (laser pointer) - High (visual marker)	Medium (GPS) - High (Bluetooth)	Medium (short identifier) - High (long identifier)
Fun factor	High	High	Medium (Bluetooth) - High (GPS)	Low
Innovativeness	High	High	High	Low

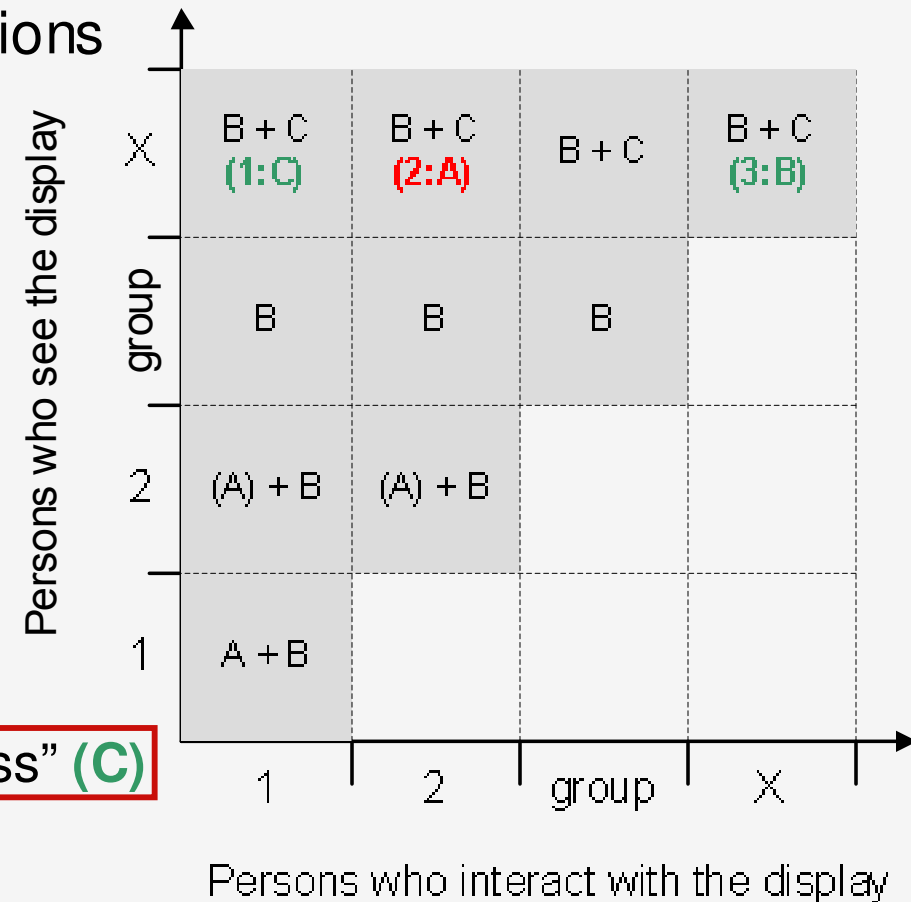
- Structure: case studies → experiences, best practices, guidelines, techniques and methods

User-centered design process phase	Technique	
Specify context of use and requirements	Field studies	
	Unobtrusive contextual observation	
	Online survey	
Produce design solutions	Low- fidelity prototypes	Paper prototyping
		HTML/Flash prototyping
	High- fidelity prototypes	Using off-the-shelf mobile devices for domain specific information appliances
		The Physical User Interface Profile (PUIP)
	Development of context-aware mobile systems	
Evaluate designs	Laboratory studies	
	Field studies	

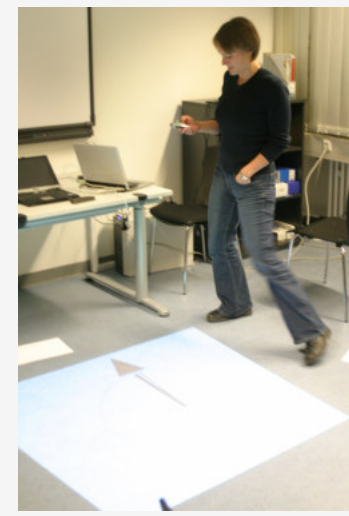
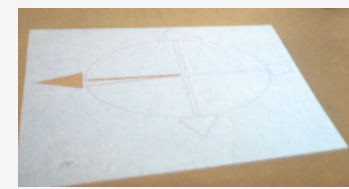
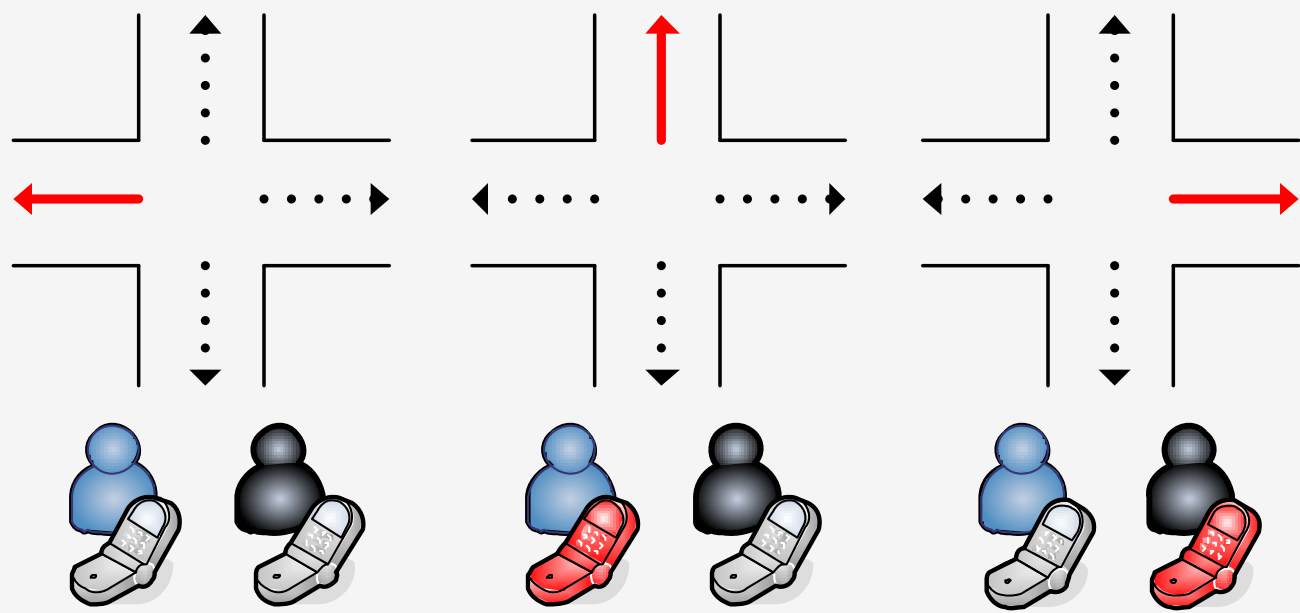
- Paper prototype: cheap and fast evaluation of application concept
 - No proof that application concept will be successful
 - But: reveal application concepts that will not be accepted by the user / costumer
- Lessons learned
 - Simulation of physical mobile interactions (view finder, touching)
 - Augmenting a real mobile device
 - Realistic vs. quick and dirty screens



- Application of physical mobile interactions
- Personalization, privacy and curiosity
 - A: Personalized information that must not be shown in public
 - B: Personalized information that can be shown in public
 - C: Personalized information that can be shown in public if no link to the initiator can be drawn
- Examples
 1. Navigation technique “rotating compass” (C)
 2. Using a public display for exchanging and showing private pictures (A)
 3. Using a mobile device for playing a game displayed by a public display (B)



- Interaction technique for mobile navigation



- Advantages: direct mapping of the desired direction into the real world, unobtrusive: navigate without listening to or looking at the mobile device (vibration)
- Easy to understand and to use (user study: 14 participants, 12/2004)

- Definition, analysis and classification
- Physical Mobile Interaction Framework (PMIF)
 - Designed, developed, used for the implementation of seven prototypes
- Evaluation and comparison of physical mobile interaction techniques
 - Advantages and disadvantages in different contexts
- Experiences, best practices, guidelines, techniques and methods that support the development of physical mobile applications
 - Specifying context of use and requirements, producing design solutions, evaluating systems
- Mobile interaction with public displays
 - Personalization, privacy, curiosity
 - Two new interaction techniques developed and evaluated: rotating compass and direct touch-based interaction with dynamic displays

- Application of results so far
 - Co-inventor in patent applications: two submitted and one in preparation
 - Usage of PMIF in research projects (Perci, SMS, Intermedia)
- Future Work
 - New physical mobile interactions
 - Mobile device technology in new housings
 - Authoring tools for mobile applications
 - Augmenting the real world
 - Human - computer vs. computer - real world interaction
 - Multi-user and long-term studies
- Questions?

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