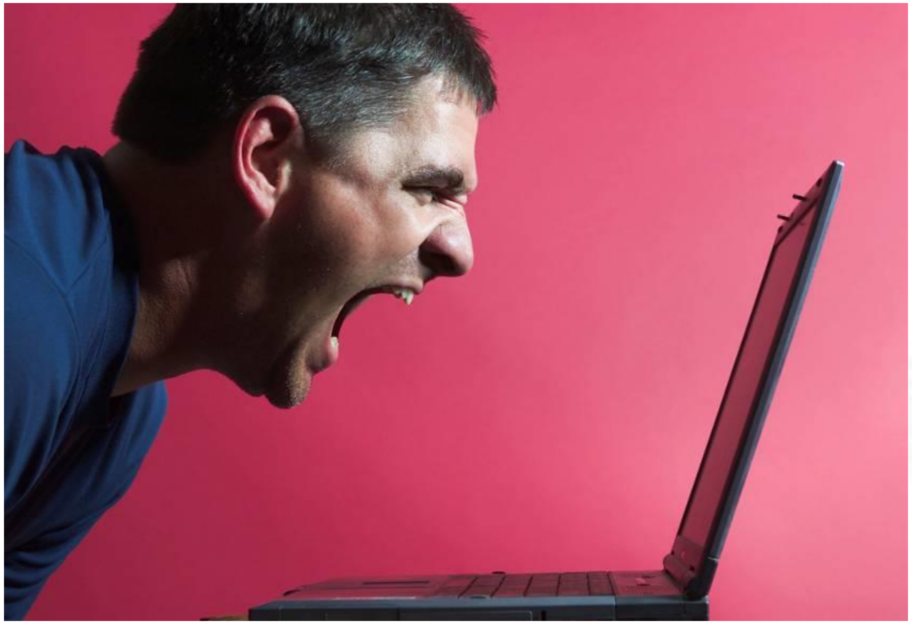
Lecture 11

Design of Mobile Applications & Services: HCI Issues



Mobile Business II (SS 2025)

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Goethe University Frankfurt a. M.

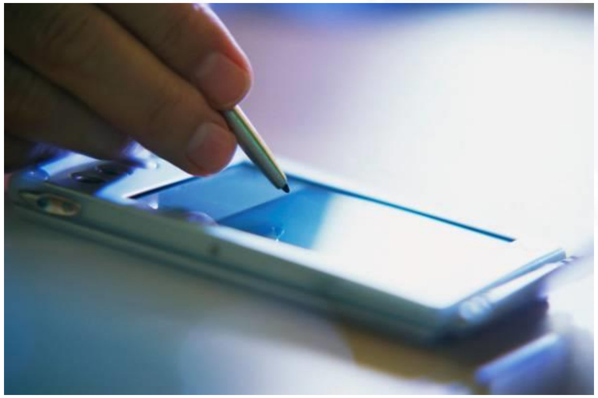
Agenda

- Introduction to HCI
- Mobile Interaction Styles
- Mobile Interaction Design
  - Understanding Users
  - Developing Prototype Designs
  - Evaluation
- Examples: Enhanced App Store, Privacy Guide and App Analyzer

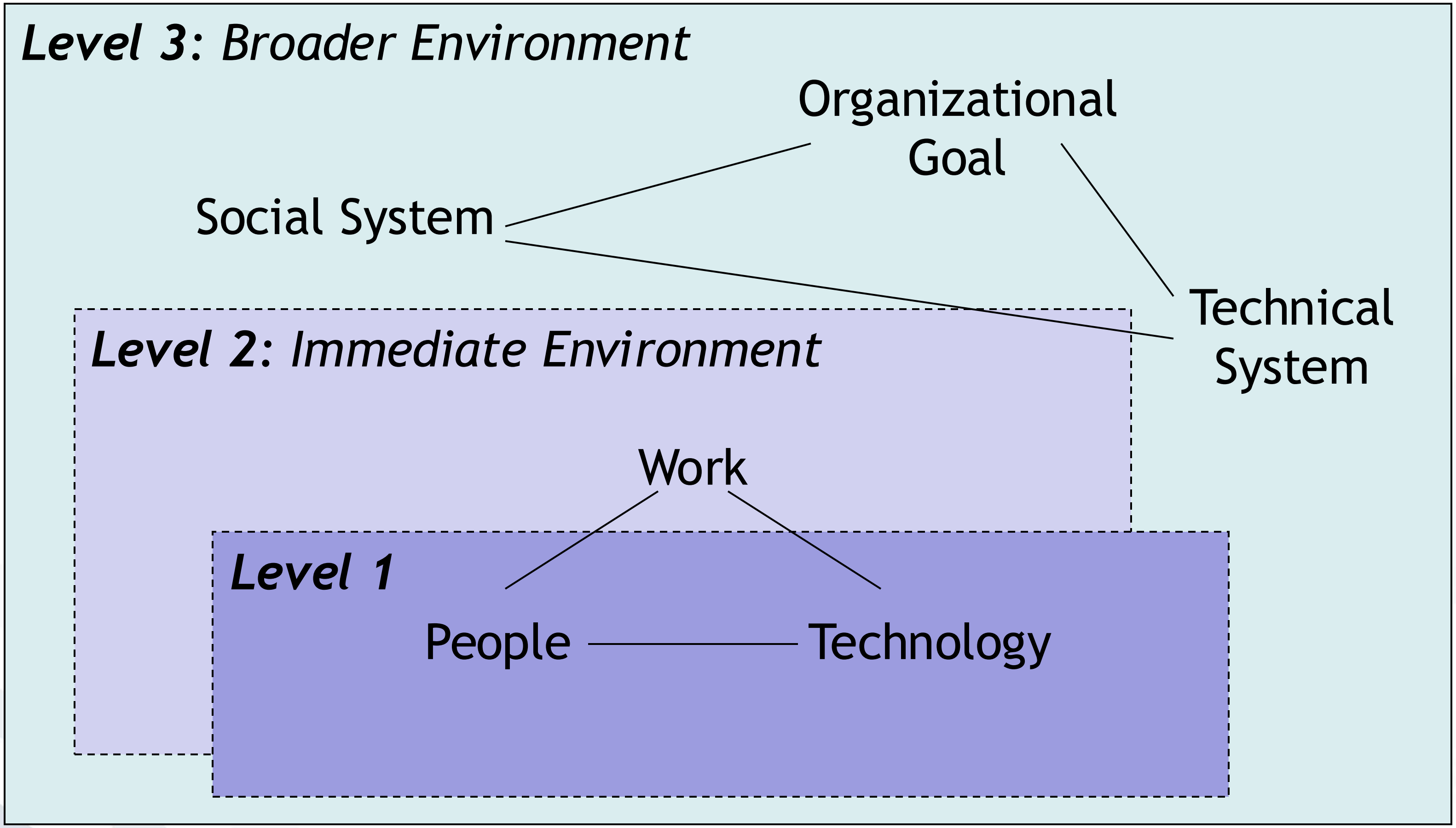
HCI | Definition

"Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them."
[Hewett et al. 1992]

"Human-computer interaction is the scientific study of the interaction between people, computers, and the work environment."
[BeardPeterson1988]



Focus of HCI



[Preece et al. 1994]

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Definition of Usability

Usability is the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use."

[ISO9241]

Elements of Usability Definition

- **Effectiveness**: Accuracy and completeness with which users achieve specified goals.
- **Efficiency**: Resources expended in relation to the accuracy and completeness with which users achieve goals.
- **Satisfaction**: Freedom from discomfort, and positive attitudes towards the use of the product.
- **Context of use**: Users, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used.
- **User**: Person who interacts with the product.
- **Goal**: Intended outcome.
- **Task**: Activities required to achieve a goal.
- **Product**: Part of the equipment (hardware, software and materials) for which usability is to be specified or evaluated.

[ISO9241]

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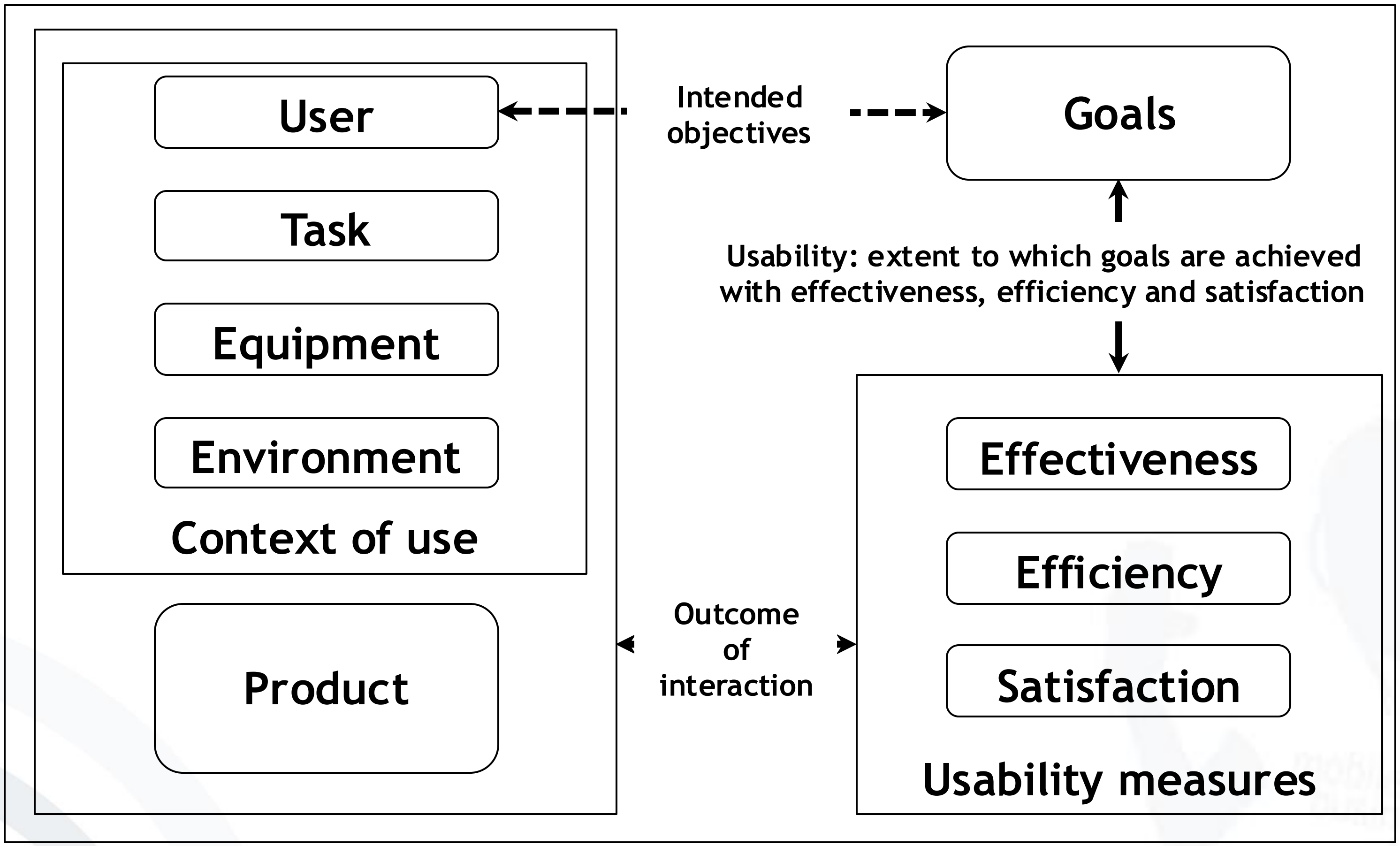
Usability Framework



[ISO9241]

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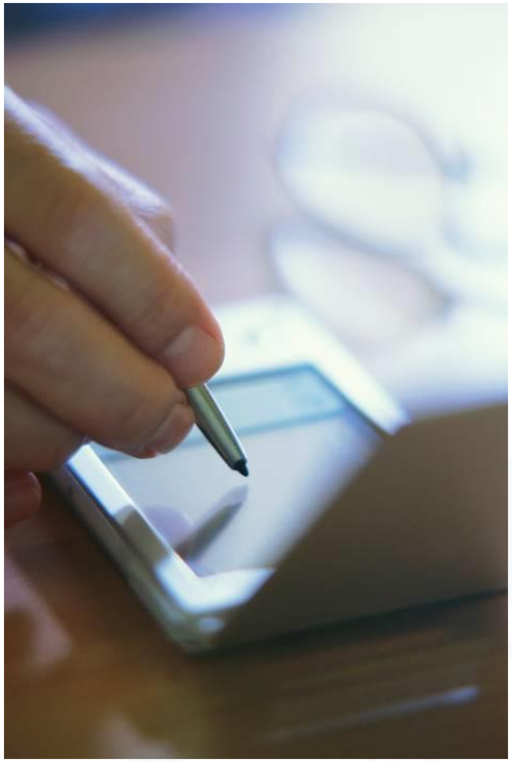
Mobile Interaction Styles

The interaction between users and mobile devices is multidimensional:

- Text entry
- Speech input
- Menu navigation
- MultiTouch
- Earcons
- Metaphors



Source: **[Love2005]**

Possible interaction via text entry:

- Keyboard entry
- Touch screen
  - Recognition of handwriting
  - Palm-Graffiti
  - Virtual keyboard
  - Swype
- Tegic T9
- Octave
- …

Mobile Interaction Styles
Text Entry - Keyboard

- Text entry via classic keyboard solution.
- For higher mobility, keyboards become foldable and virtual.

[TAPWITHUS]

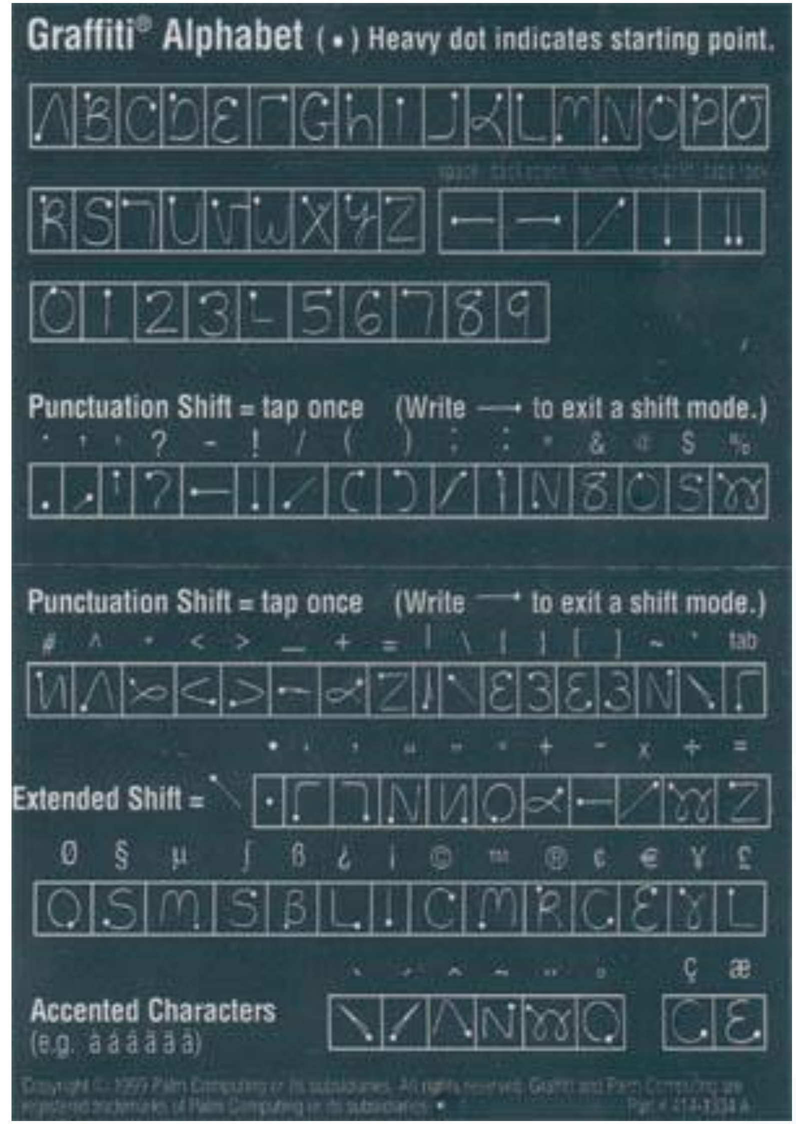
[Palm]

[BSTQC]

➲ Adaptation of a traditional text entry concept

Mobile Interaction Styles
Text Entry - Touch Screen

- Handwriting recognition software
- Artificial script, based on upper-case characters
- Can be drawn blindly with a stylus on a touch-sensitive panel



[U.S.Robotics]

Mobile Interaction Styles

Text Entry - Touch Screen – Virtual keyboard

- Virtual keyboard on the screen
- Can be used with a stylus or with fingers

[HTC, Inc]

Mobile Interaction Styles

Text Entry - Swype

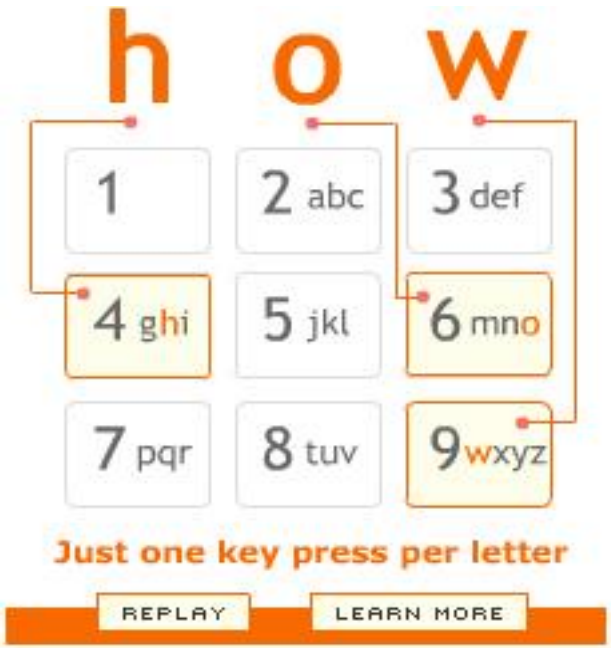
- Swype is an input method for touch screens developed by Swype Inc.
- Available on Samsung, HTC, and also on Android and Symbian.
- Three major components: An input path analyzer, word search engine with corresponding database, and a manufacturer customizable interface.
- Available in >40 languages.

[SOYACINCAU]

Mobile Interaction Styles

Text Entry - Tegic Communications T9

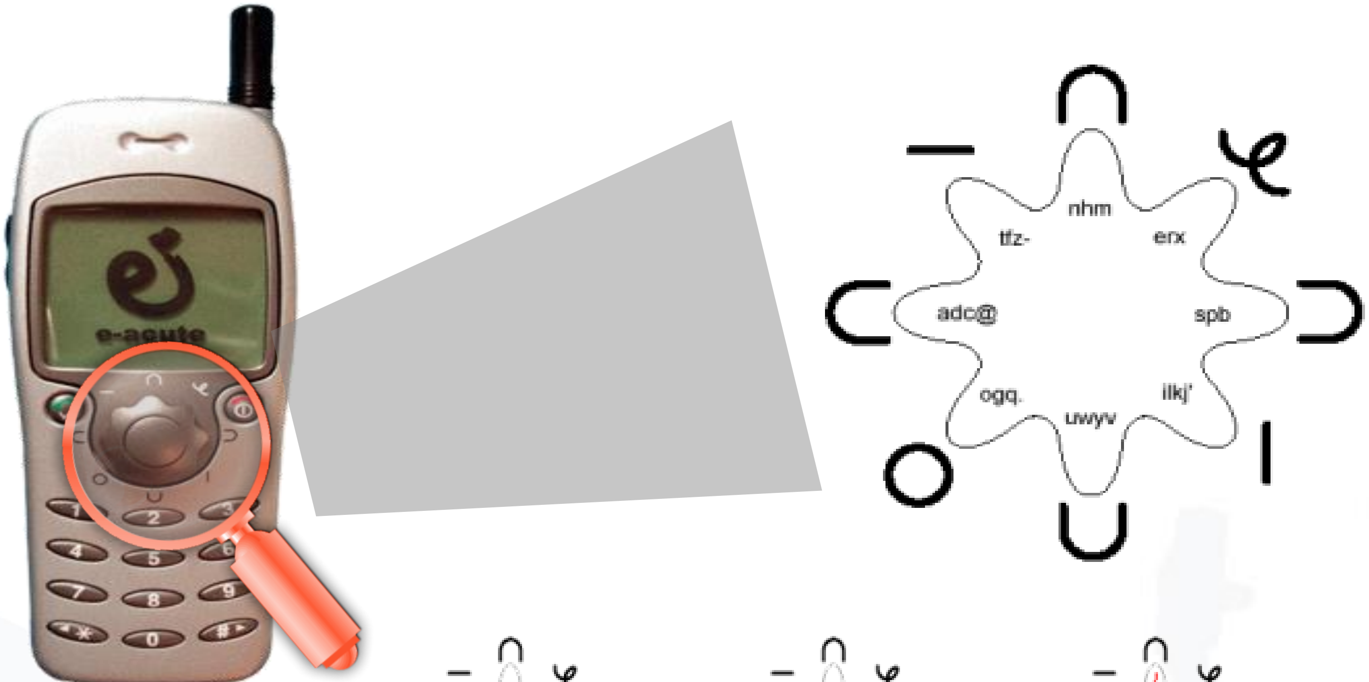
- T9 (*Text on 9 keys)* is a predictive text technology developed by Tegic Communications.
- Widely used by: LG, Samsung, Nokia, Siemens, Sony Ericsson, Sanyo
- Uses a dictionary of words, which is used to look up all the possible words, corresponding to the sequence of keys pressed.
- Available in 27 languages

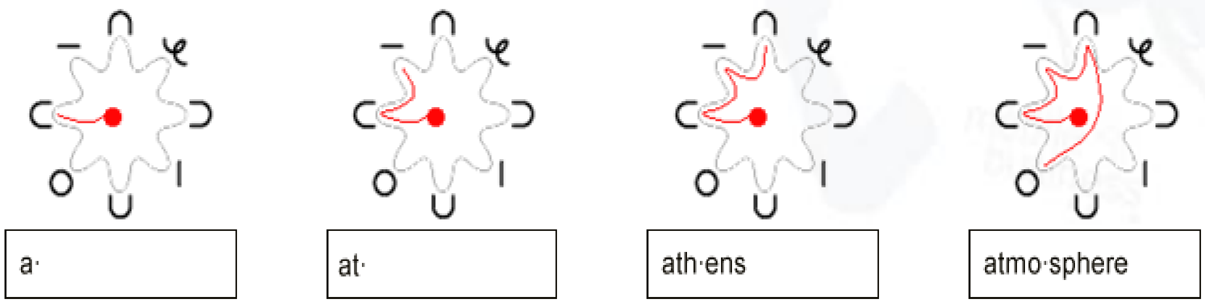


[Thaimobile]

Mobile Interaction Styles
Text Entry - Octave

- Text can be entered via key navigation





Mobile Interaction Styles
Speech Input

- Speech input relies on speech recognition technologies used by the mobile application.
  - *Speaker-dependent*
    Recognition technologies "learns" from a set of sample words spoken by the user (system training).
  - *Speaker-independent*
    Pre-defined vocabulary that has been set up by a large number of speech samples.

Source: **[Love2005]**

Mobile Interaction Styles
Menu Navigation

- Mobile phone applications usually have a hierarchically structured navigation menu providing a list of menu choices.
- Menu hierarchies are often not self-explanatory (switching costs for users).
- Long menu lists can overload the users' short-term memory.

connect your memory card to a computer

You can use a cable connection to access your phone's memory card with a PC.

Note: When your phone is connected to a computer, you can only access the memory card through the computer.

On your phone:

Disconnect the cable from your phone, if it is connected, then press ·◆· > Settings > Connection > USB Settings > Default Connection > Memory Card.

This directs the USB connection to your memory card.

[Motorola]

Mobile Interaction Styles
Touch Screen – Multi-touch

- Input by using gestures
- Up to three (or more) fingers simultaneously

[Wikipedia]

Mobile Interaction Styles
Earcons

- Earcons are abstract musical tones that produce sound messages to represent parts of an interface.

- Event-driven:
  - Incoming text messages
  - Alarm clock
  - …

- Menus augmented with earcons can support user navigation.

Mobile Interaction Styles
Metaphors

- Interface metaphors work by applying prior knowledge from a familiar to a new domain.
- Goal: Reducing people’s perception of the complexity of the device used.

  [Love2005]

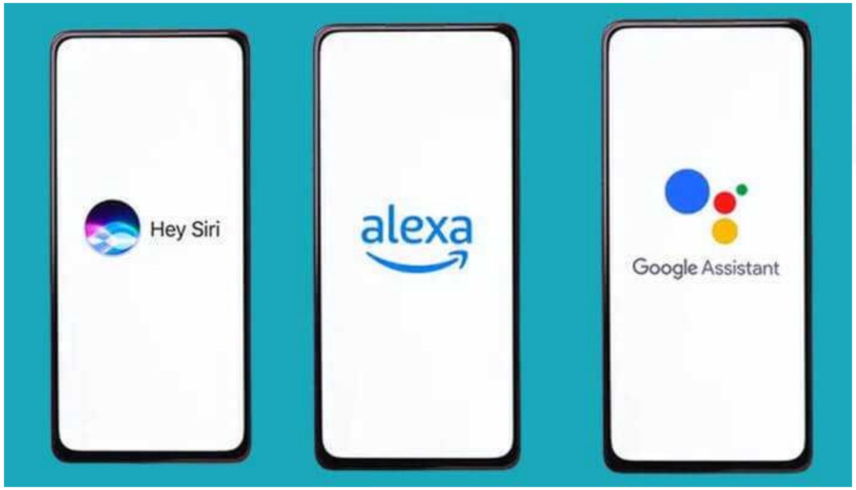
[Nokia]

Emerging Mobile Interaction Styles (2020–2024)

- Voice Conversational Interfaces
- Gesture-Based Interaction
- Emotion-aware/Haptics
- Mobile Augmented Reality Interfaces
- Mobile Brain-Computer Interfaces

Voice Conversational Interfaces

- Utilization of AI-powered voice assistants (e.g., Siri, Google Assistant, Alexa) that enable natural dialogue-based interaction.
- Moving beyond command-response to contextual and adaptive conversations.
- Particularly relevant for hands-free mobile use (e.g., driving, multitasking).



[Hoy, M. B. 2018]

Gesture-Based Interaction

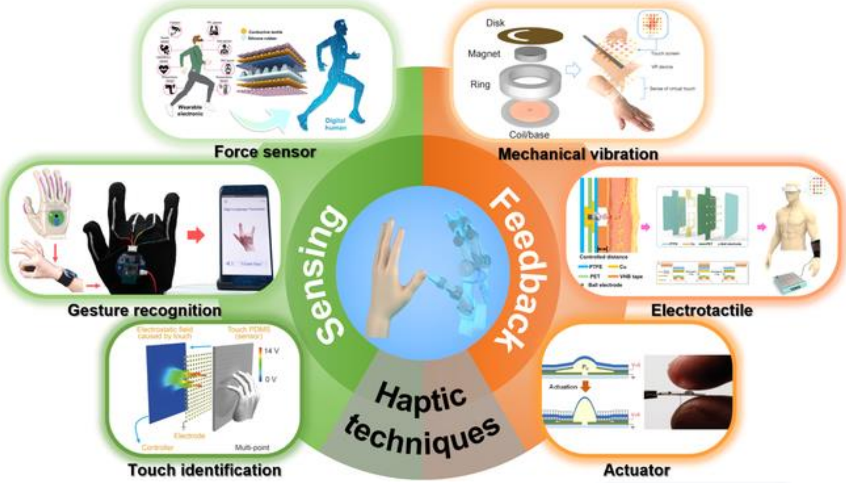
- Mobile devices now use front-facing cameras and LiDAR for gesture recognition (e.g., air swipe, nodding).
- Enables interaction without physical contact—important for AR/VR, accessibility, and hygiene.

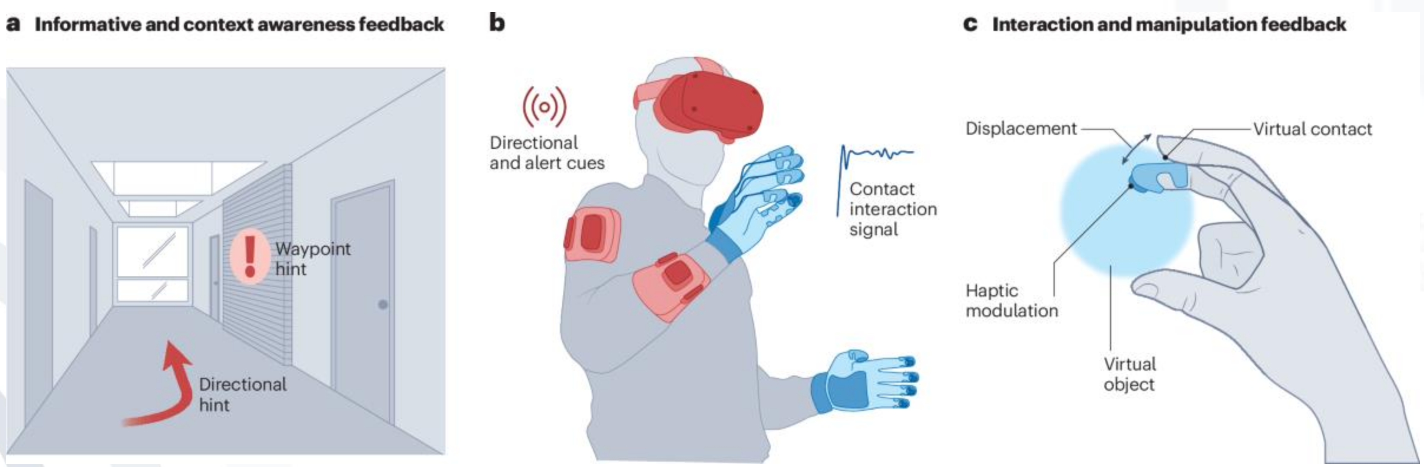
Zooming in and out using Gesture Recognition Technology

[EFYBureau]

Emotion-aware/Haptics

- Advanced haptic motors simulate textures, resistance, and emotional states (e.g., vibrations for stress or urgency).
- Includes wearable feedback for immersive mobile interactions (e.g., smartwatches, AR/VR controllers).

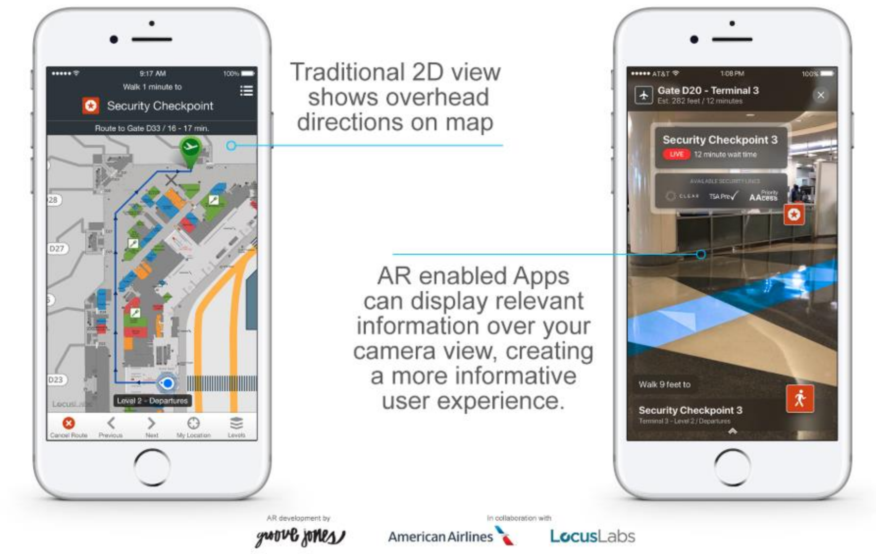


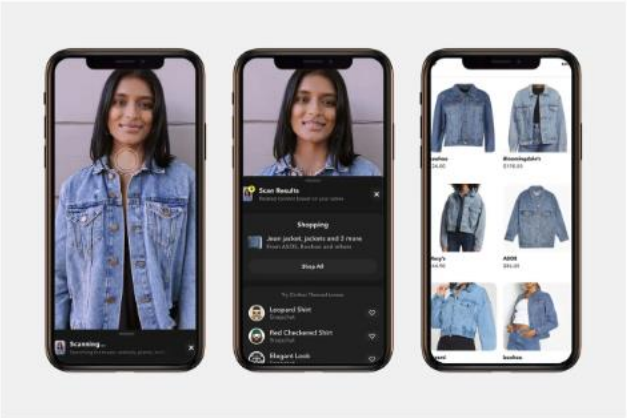


[Shi&Shen2024; Frisole&Leonardis2024]

Augmented Reality Interfaces

- Mobile AR overlays information on the real world via smartphone cameras.
- Popularized by Google ARCore, Apple ARKit, Snap AR.

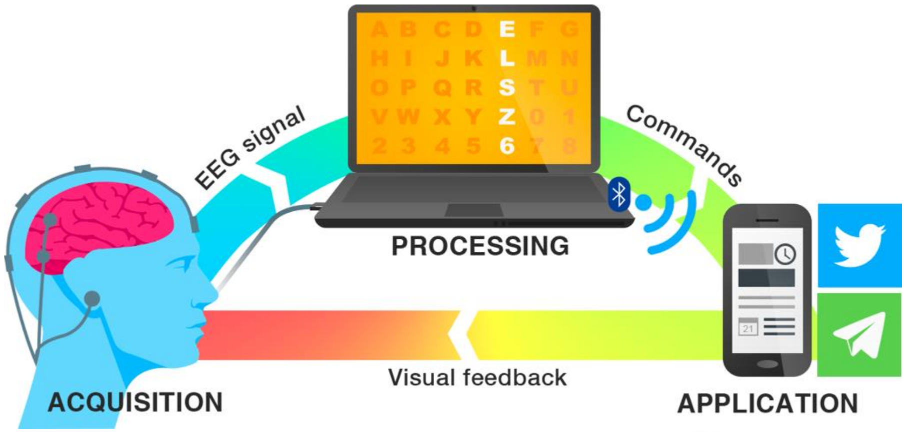


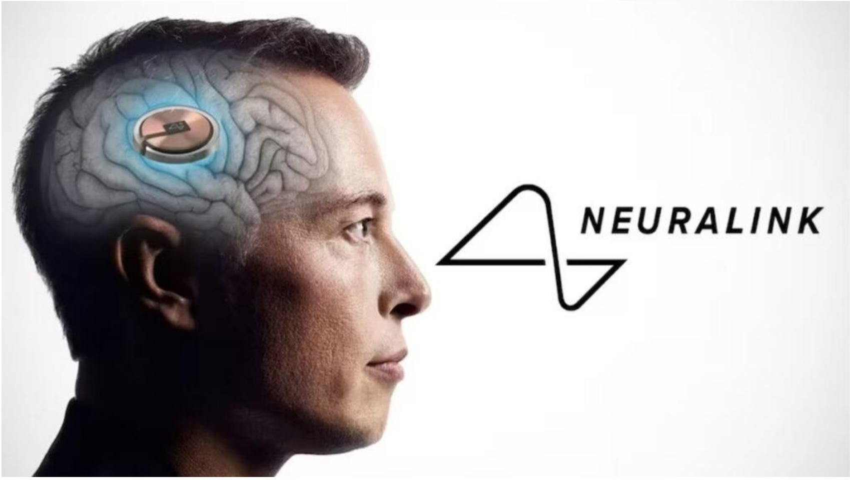


Snapchat users will now be able to try on clothing, glasses, purses and bracelets virtually. Snapchat

Brain-Computer Interface (BCI) on Mobile Devices

- Non-invasive BCIs (e.g., EEG headsets) linked to mobile devices enable neural input control.
- Emerging research shows promise in accessibility and immersive control.
- Enables individuals with ALS, spinal cord injuries, or severe paralysis to communicate, interact, and express creativity—enhancing autonomy and quality of life.





[Cagigal2018]

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Main activities of effective interaction design

Understanding users
(Capabilities and limitations)

Developing prototype designs
(Demonstration of proposed interaction design)

Evaluation
(Identification of strengths and weaknesses of a design)

[JonesMarsden2006]

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Mobile Interaction Design
Understanding Users |1

- For an effective interaction design, it is necessary to understand potential users of a system.

- Possible methodologies
  - Field studies (observe and probe a particular group in situations of interest)
  - Laboratory experiments (observe and probe a particular group within a controlled environment)
  - Direct questionnaire (e.g. to validate impressions and interpretations from the field)

- The user group needs to have a significant impact on the design process.
- User-centered service design can significantly affect the user's perception of mobile devices and services.
- Examples of user characteristics:
  - **Spatial ability:**
    dealing with spatial relations and visualization of spatial tasks
  - **Verbal ability:**
    comprehend spoken or written words
  - **Working memory:**
    limited capacity of short-term memory
  - **Previous experience:**
    user's experience with an actual interface used

[JonesMarsden2006]

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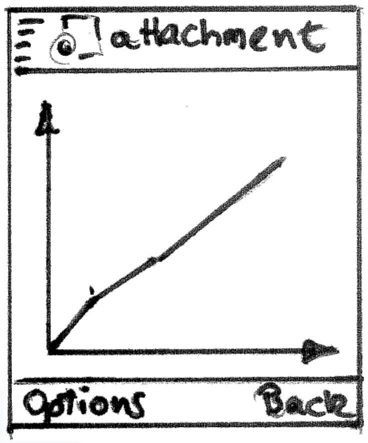
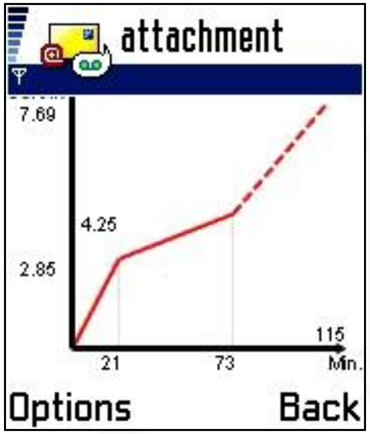
Mobile Interaction Design

Developing Prototype Designs |1

- HCI-Prototypes are built in order to express a design idea as quickly as possible.
- One can differentiate how closely a prototype resembles the appearance of the final product.

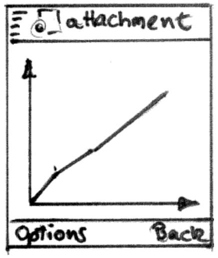




Low-fidelity

High-fidelity

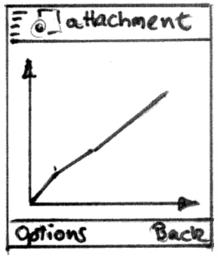
[JonesMarsden2006]



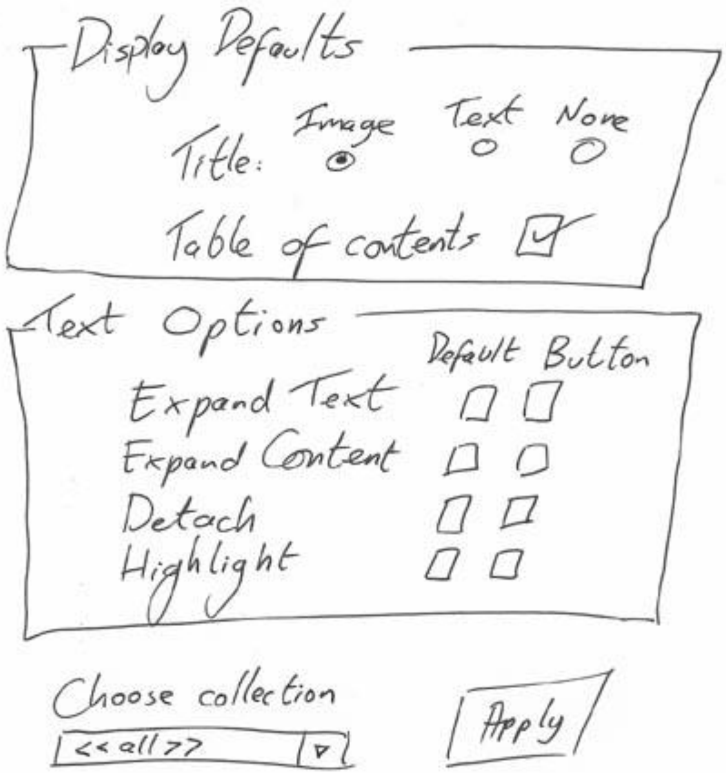
Low-fidelity

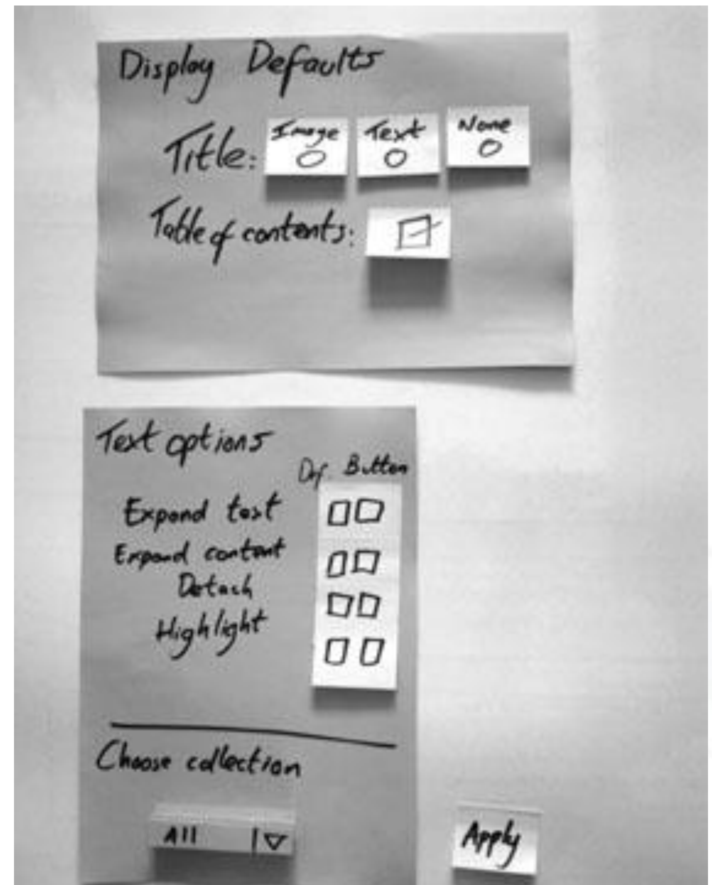
The prototype uses materials different to those in the final incarnation.

- Check for inconsistency
- Give a common specification for the design team
- Afford reflection
- Check interaction scenarios

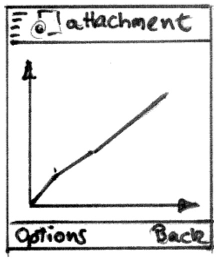


Basic Layouts





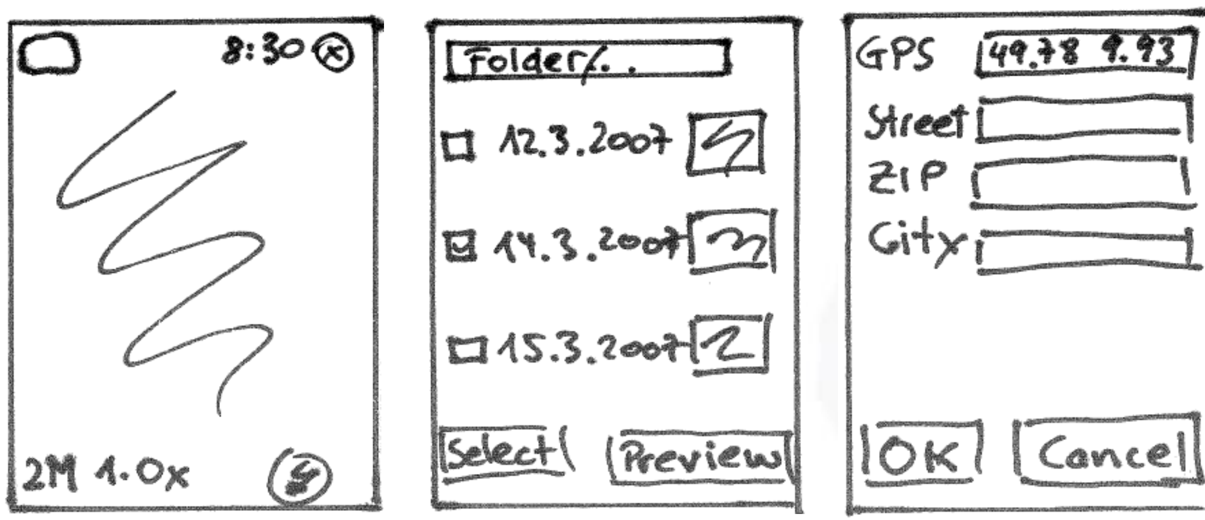
Source: www.wiley.com/go/mobile



Self-Checking

Building a low-fidelity prototype for testing the feasibility of ideas

Example:

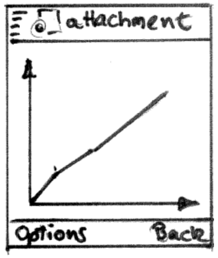


Take pictures

Choose a picture

Get location via GPS or manual input

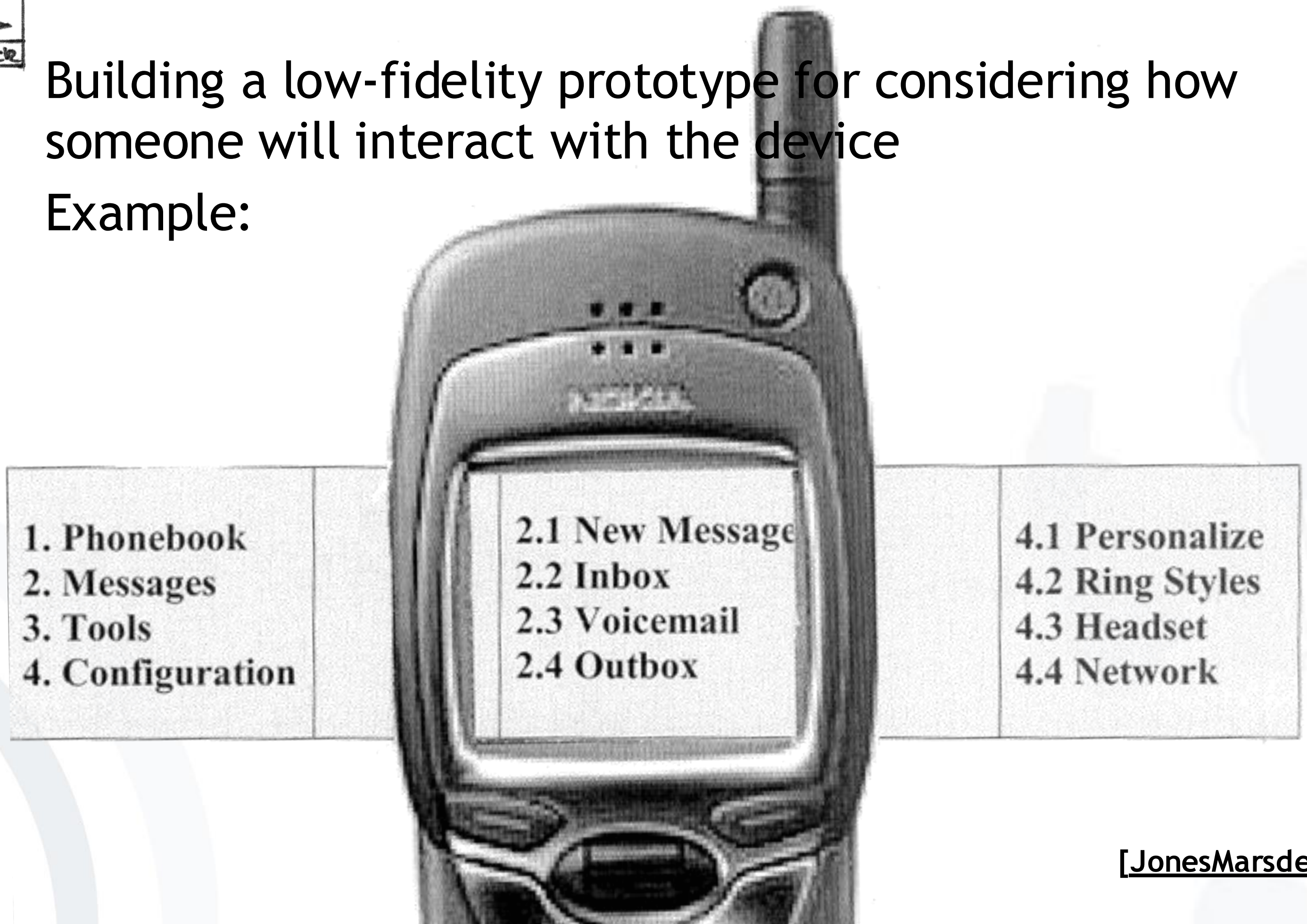
[JonesMarsden2006]



Interaction prototyping

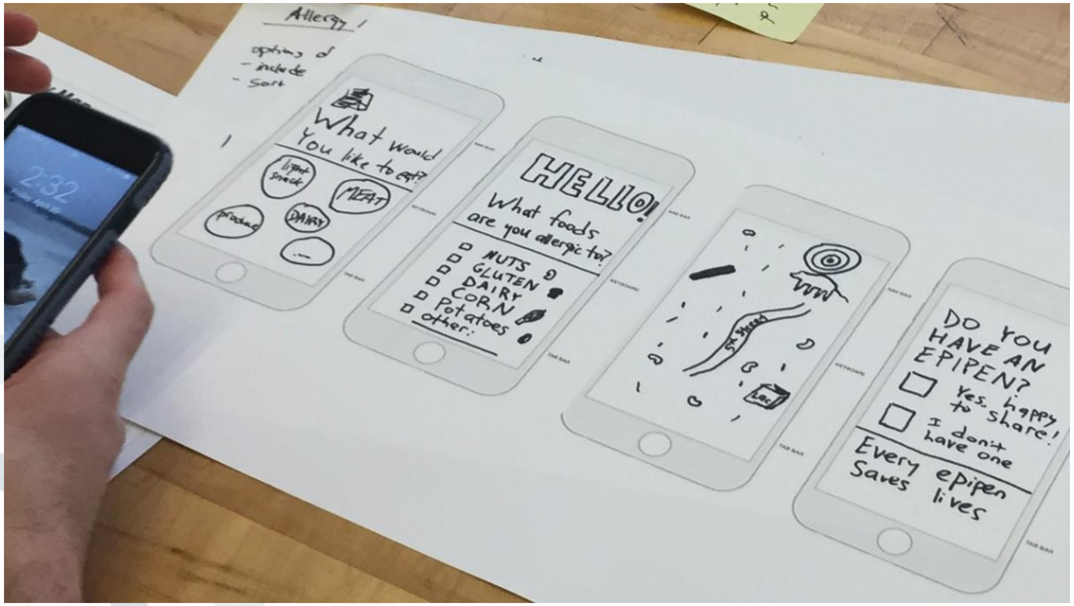
Building a low-fidelity prototype for considering how someone will interact with the device

Example:



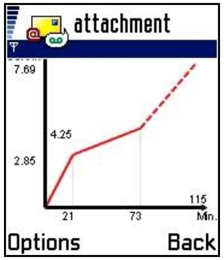
[JonesMarsden2006]

- New tools massively simplify low-fidelity prototyping
- For example: Pop by Marvel[1]
→ sketches can be turned into an interactive iOS or Android prototype



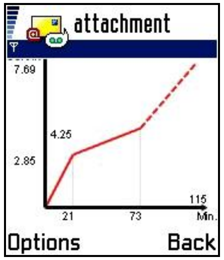
Exemplary use of app: http://vondesign.com/category/drawing

[1]https://marvelapp.com/pop/



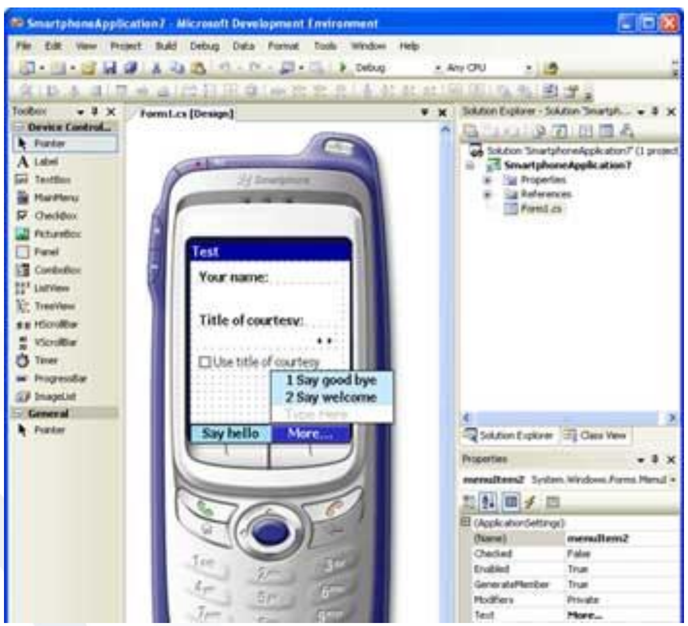
High-fidelity

- The results of a low-fidelity prototyping process comprise a list of features that should be tested with representatives of the target group.
- High-fidelity prototype designs provide the functionality to evaluate critical tasks and functionalities that should be supported by the final product.
- Therefore, most critical features must be identified to be included in the prototype design.

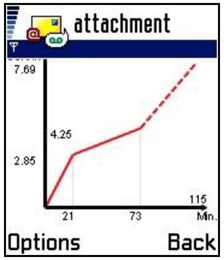


PC-based prototype designs...

… can be developed by using standard programming environments (e.g. Visual Studio) and software emulators



[Diego]



Platform-specific prototype designs

… can provide a proof-of-concept and can be used for evaluations

Take pictures **Choose a picture** **Get location via GPS or manual input**

[Fritsch et al. 2005]

Mobile Interaction Design
Key Issues in HCI Prototyping

Type	Advantages	Disadvantages
Low-fidelity	▪ Less time ▪ Lower costs ▪ Evaluate multiple concepts ▪ Useful for communication ▪ Address screen layout issues	▪ Little use for usability test ▪ Navigation and flow limitation ▪ Facilitator driven ▪ Poor detail in specification
High-fidelity	▪ Partial functionality ▪ Interactive ▪ User-driven ▪ Clearly defined navigation scheme ▪ Use for exploration and test ▪ Marketing tool	▪ Creation time-consuming ▪ Inefficient for proof-of-concept ▪ Blinds users for major representational flaws ▪ Users may think prototype is 'real'

[JonesMarsden2006]

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Why evaluation?

- Understanding how users will use the design in the real world,
- Comparing different prototype designs,
- Assessing whether the product to be developed meets usability requirements, and
- Ensuring that the product conforms to industry standards.

Source: **[Love2005]**

Mobile Interaction Design

Evaluation |2

- The evaluation of HCI prototype designs can be based on different methodologies addressing different aspects, e.g.:

  - Direct observation
  - Interviews
  - Questionnaires
  - Experiments
  - …

[JonesMarsden2006]

Direct observation

Observe or video users how they use the HCI design in order to check, for e.g. the:

- intuitive and correct usage of the design by the users,
- ability of users to manage pre-defined tasks.

- **Conducted by:** End-Users
- **Equipment:** Interactive prototype
- **Results:** Qualitative
- **Where:** Controlled setting

[JonesMarsden2006]

Interviews

- Often made in conjunction with observations
- Provision of direct feedback from the users
- Observed problems can be addressed

- **Conducted by:** End-Users
- **Equipment:** Interactive prototype
- **Results**: Qualitative
- **Where**: Controlled setting

[JonesMarsden2006]

Questionnaires

- Tool for gathering users' opinions
- Tool for comparing different designs by using quality scales
- Example: *I was able to enter text easily*

  Disagree [1] [2] [3] [4] [5] Agree

- **Conducted by:** End-Users
- **Equipment**: Interactive prototype & Questionnaire
- **Results**: Qualitative & Quantitative
- **Where**: Controlled setting

[JonesMarsden2006]

Experiments

- Usually hypothesis-based
  (e.g. *Navigation within application A is quicker than within application B.*)
- Results provide insight on how much 'better' a certain design is

> - **Conducted by:** End-Users
> - **Equipment:** Interactive prototype
> - **Results:** Qualitative
> - **Where:** Controlled setting

[JonesMarsden2006]

- Design shortcomings of products can have different reasons, such as:
  - A lack of user-based evaluation during the design process,
  - Perceived financial costs of better design,
  - An overemphasis on technology over purpose.

Source: **[Love2005]**

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Privacy Enhanced App Store

Motivation

- ✓ Enhance **privacy transparency** and **privacy awareness** in app markets.
- ✓ Foster **informed choice** of apps.
- ✓ Integrate more effective **privacy risk indicators** into app markets.
- ✓ **Develop and evaluate** proof of concept for Google's Play Store.

[BalRannenberg 2014, Bal et al. 2015]

Google play

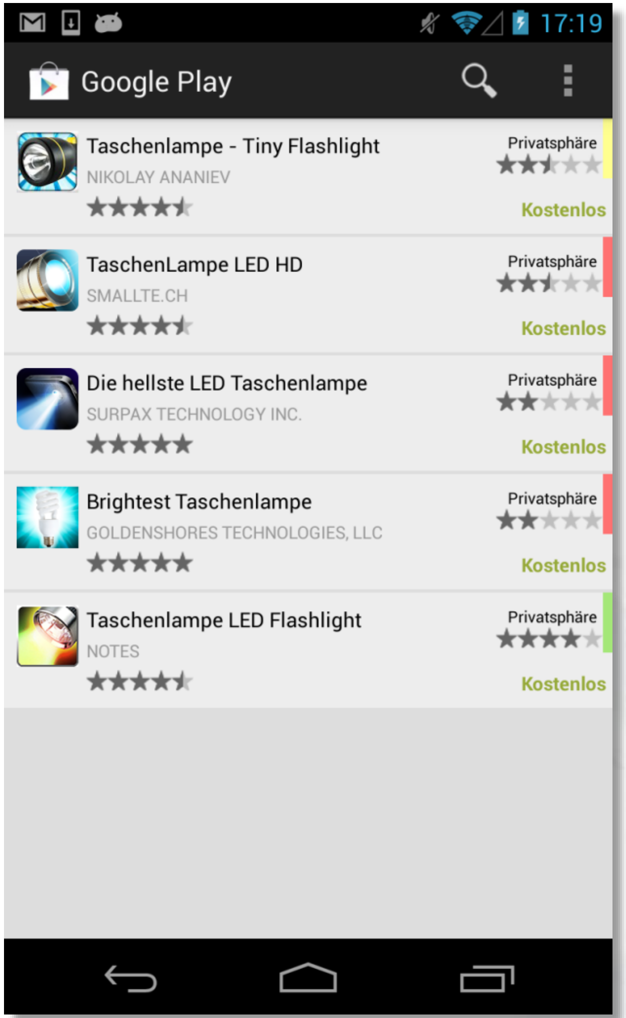
Privacy Enhanced App Store

Privacy Indicators

1. Search results enhanced with privacy score.

2. App description enhanced with visual privacy information.

3. App description enhanced with textual privacy information.



Privacy Enhanced App Store

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Privacy Enhanced App Store
Privacy Indicators

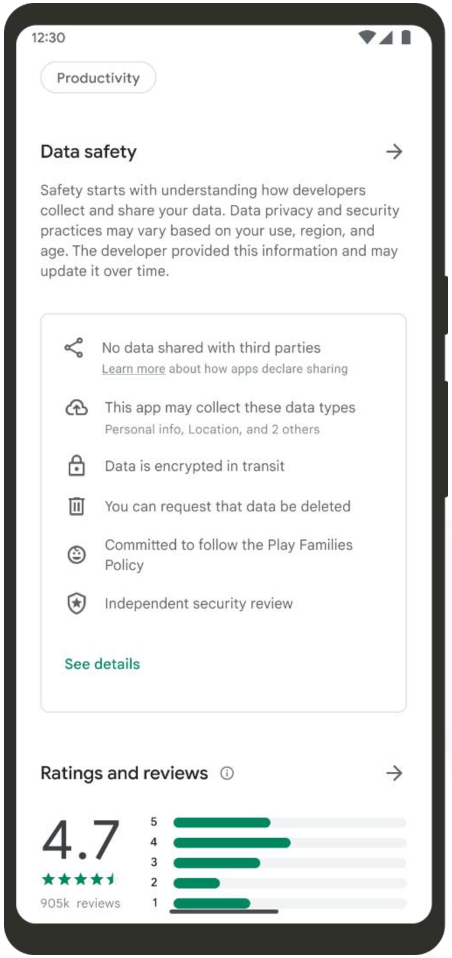
1. Search results enhanced with privacy score.

2. App description enhanced with privacy information.

3. App description enhanced with textual privacy information.

Google Play – Data Safety Section (since 2022)

- **Purpose**: Enhances transparency about app data practices **before installation.**
- **Developer Requirement:**
  Must submit detailed disclosure of:
  - **Data collection**
  - **Data sharing**
  - **Security measures**
- **User Benefit:**
  Users can **evaluate privacy risks** directly from the app's listing page.

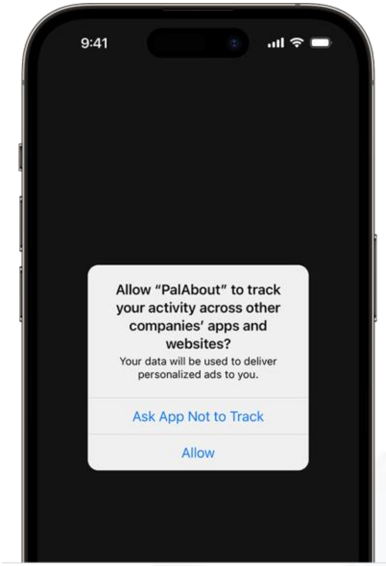


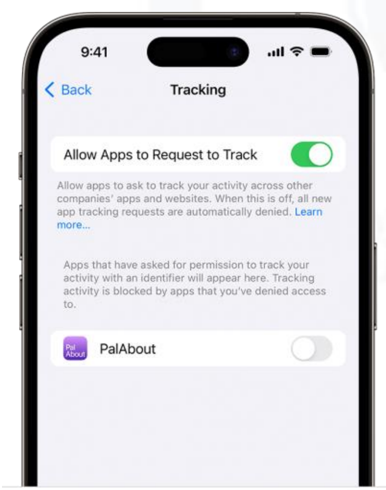
Users will see the following information if the app does not collect or share any user data with other companies or organizations.

[Google]

Apple App Tracking Transparency (ATT)

- **User Control:**
  Prompts users to **allow or deny tracking** across apps and websites.
- **If denied (“Ask App Not to Track”):**
  - **Access to** the system advertising identifier, Identifier for Advertisers (IDFA), is **blocked**
  - **Prohibits tracking** using identifiers like:
    - Email address
    - Device information
- **Goal:**
  Strengthens **user privacy** and limits **unconsented data sharing.**



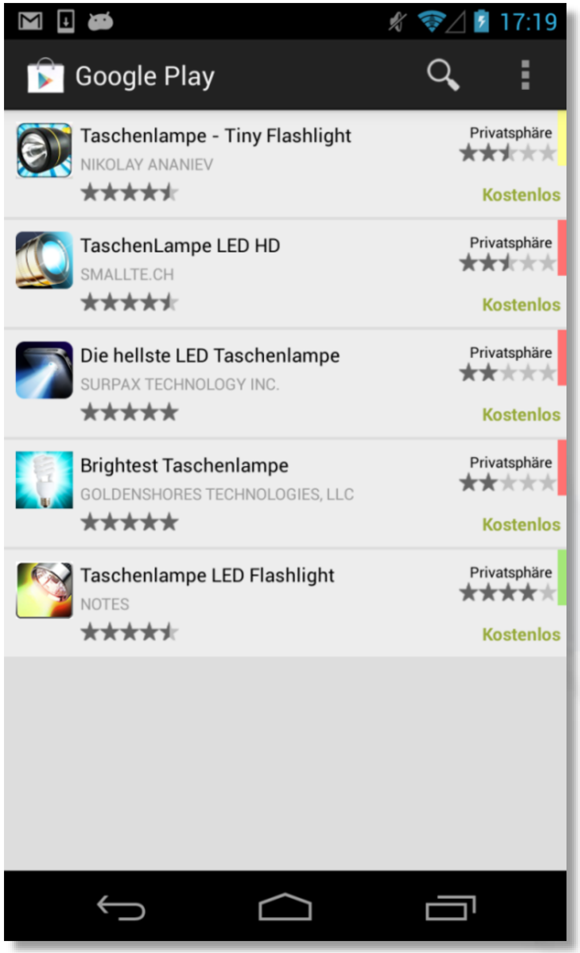


Users can tap to turn off or turn on permission to track for a specific app.

[Apple]

Privacy Enhanced App Store
Conclusion

- Result of an experimental user study: better privacy risk communication leads to:
  - increased privacy and risk awareness,
  - better comprehension of risks,
  - better comparison of apps,
  - privacy as a stronger decision factor,
  - safer app choices.



Introduction to the Privacy Guide
Problem Description

- Lack of user-friendly transparency tools, esp. with respect to data processing practices of service providers.
  - “ Users are often unaware of the information they are sharing, unaware of how it can be used by data collectors or third parties, …uncertain about their own preferences....” (Acquisti et al., 2015)

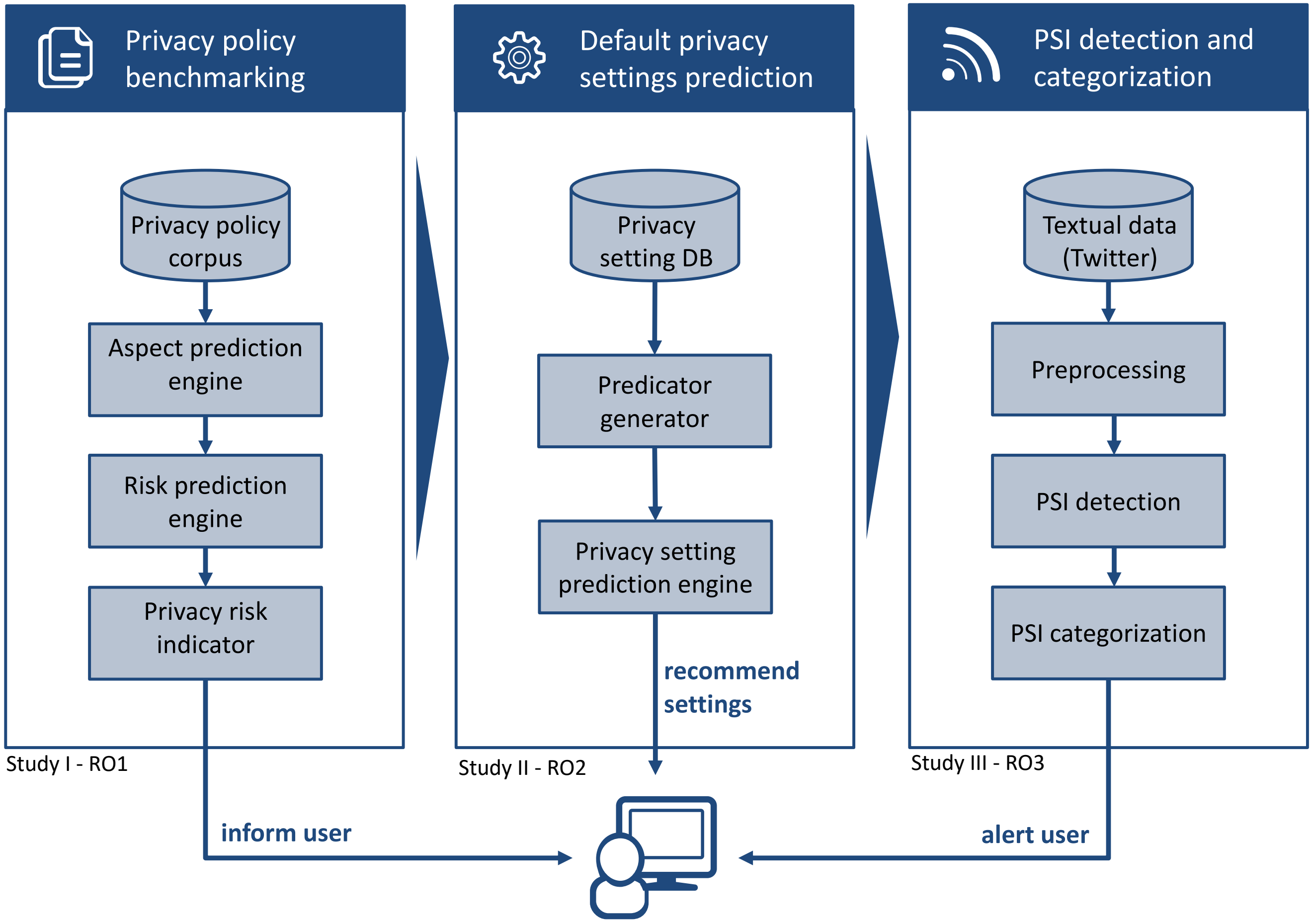
- Lengthy privacy settings (Wilson et al., 2016)
  - Generic (often) designed for max data sharing

- (Un)intended sharing of privacy sensitive information (PSI) and lack of tools to detect and inform users (Tesfay et al.,2016)
  - Discrimination based on PSI disclosure e.g. in hiring processes (Acquisti, A., & Fong, C., 2019; Neumark, 2012)

[Tesfay 2019]

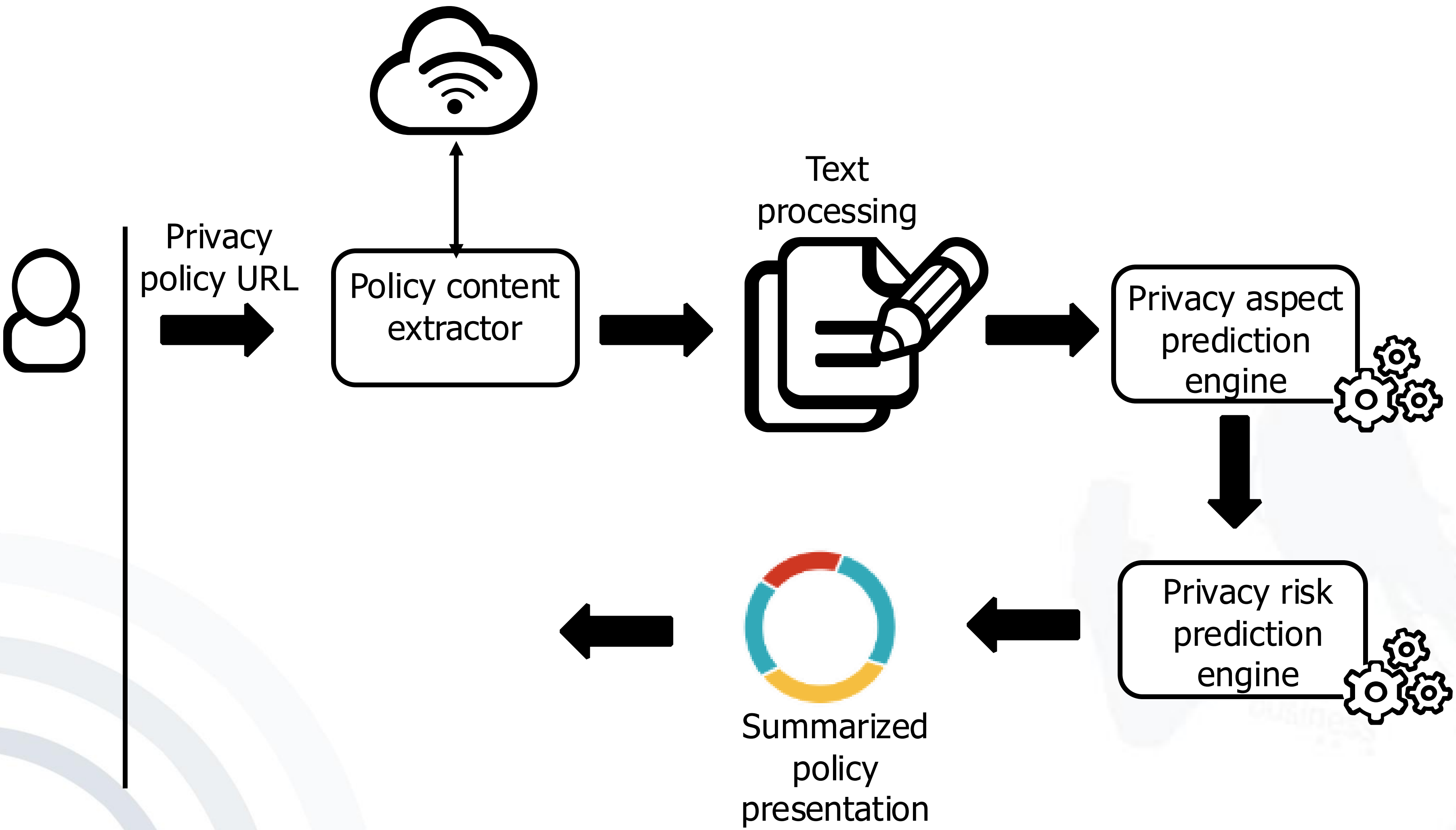
The Integrated Privacy-enhancing Framework

Simplified Schematic View



[Tesfay 2019]

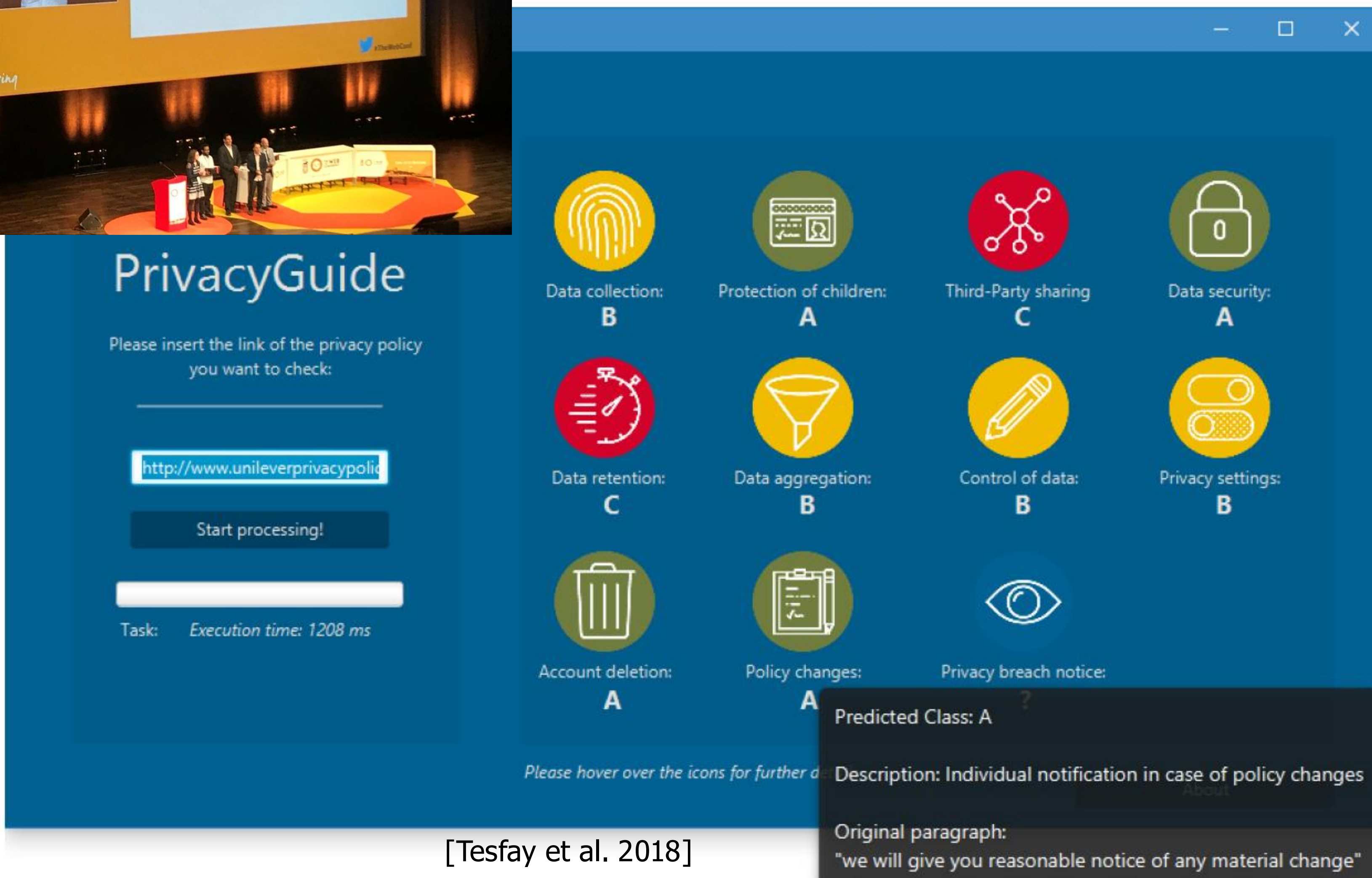
Privacy Policy Benchmarking - PrivacyGuide
Architecture



[Tesfay 2019]

PrivacyGuide

Policy analysis: PrivacyGuide results

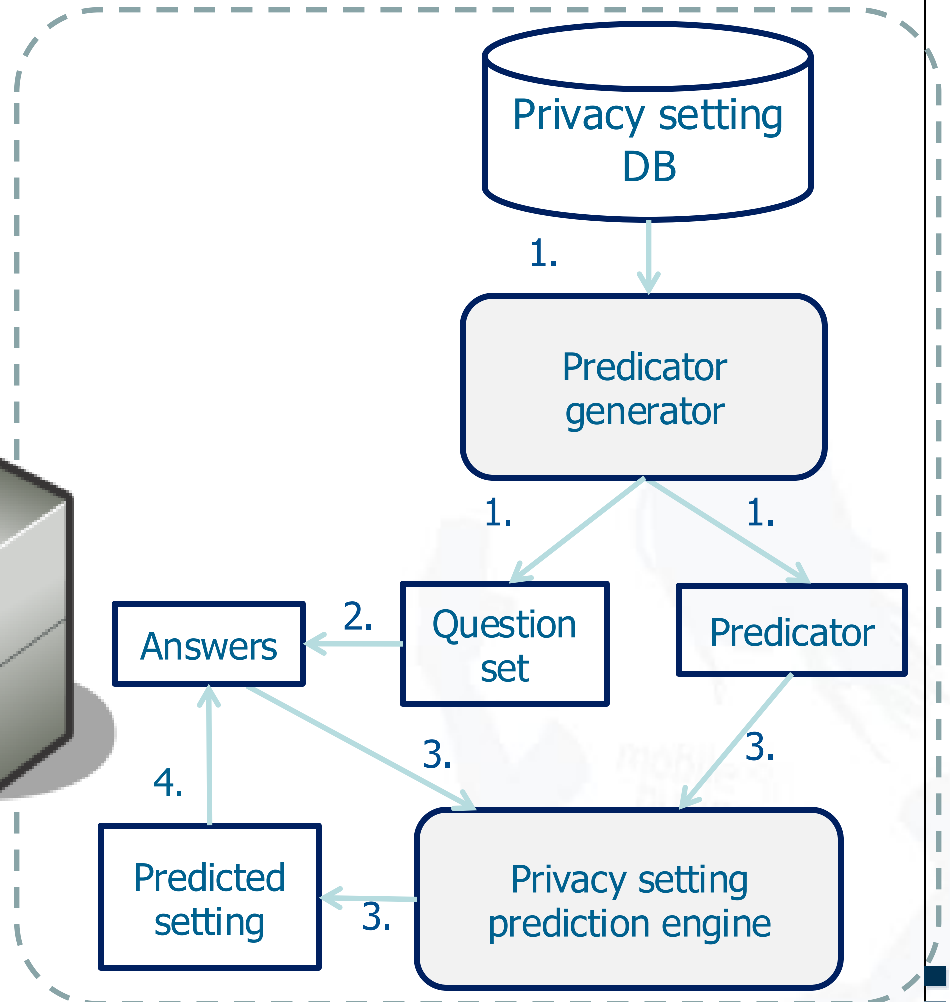


[Tesfay et al. 2018]

Default Privacy Setting Preferences Prediction

- 5 utilization purposes and 16 data types
- P3P – platform for Privacy Protection
- 10000 users

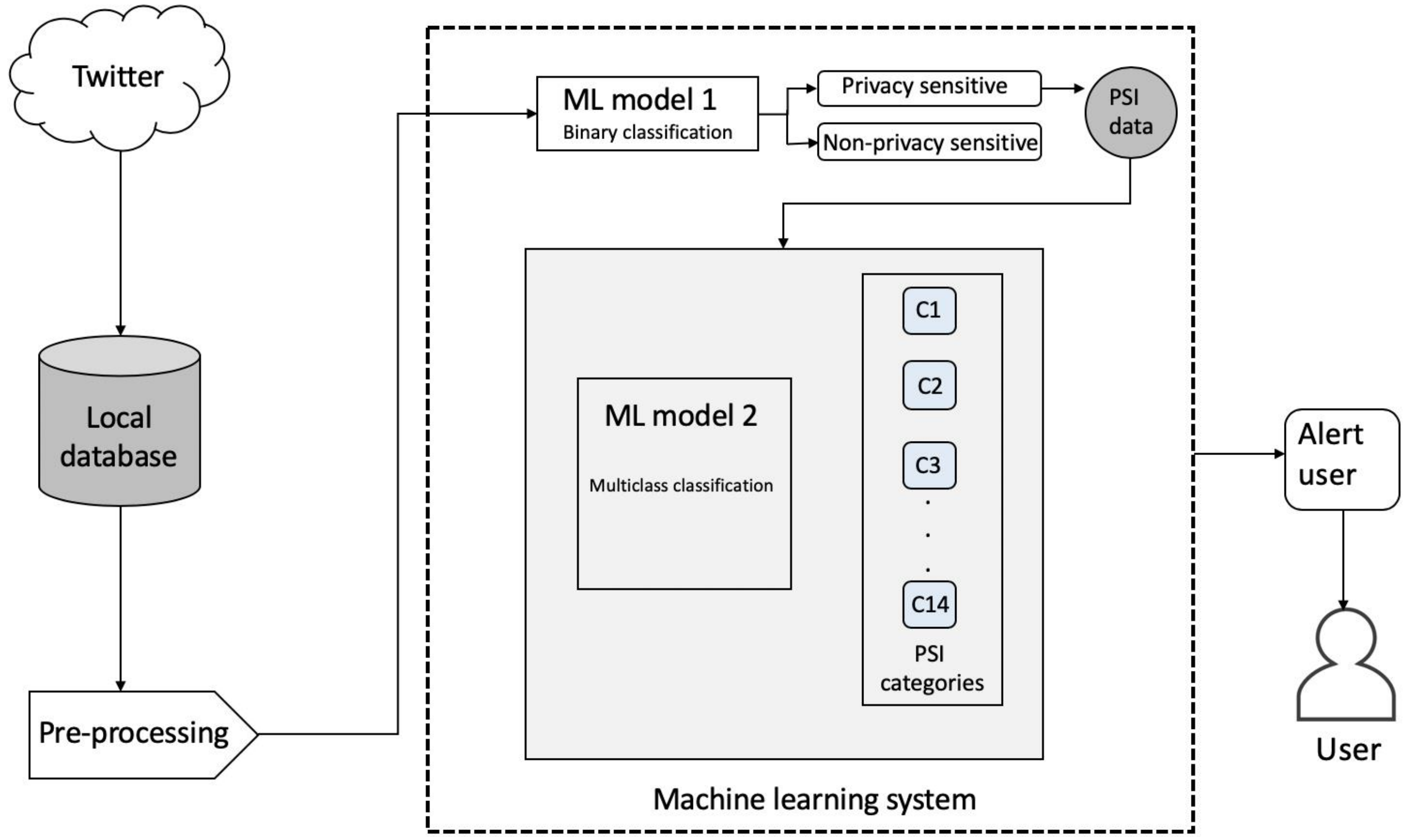
1. Generate a question set
2. Make a user answer the questions.
3. Generate predicted settings from the answers.
4. Recommend the predicted settings.



- SVM based Prediction Scheme
- Given 5 answers, predict for the rest 75 privacy setting questions
- Accuracy 85%

[Tesfay 2019]

PSI Detection and Categorization
Architecture

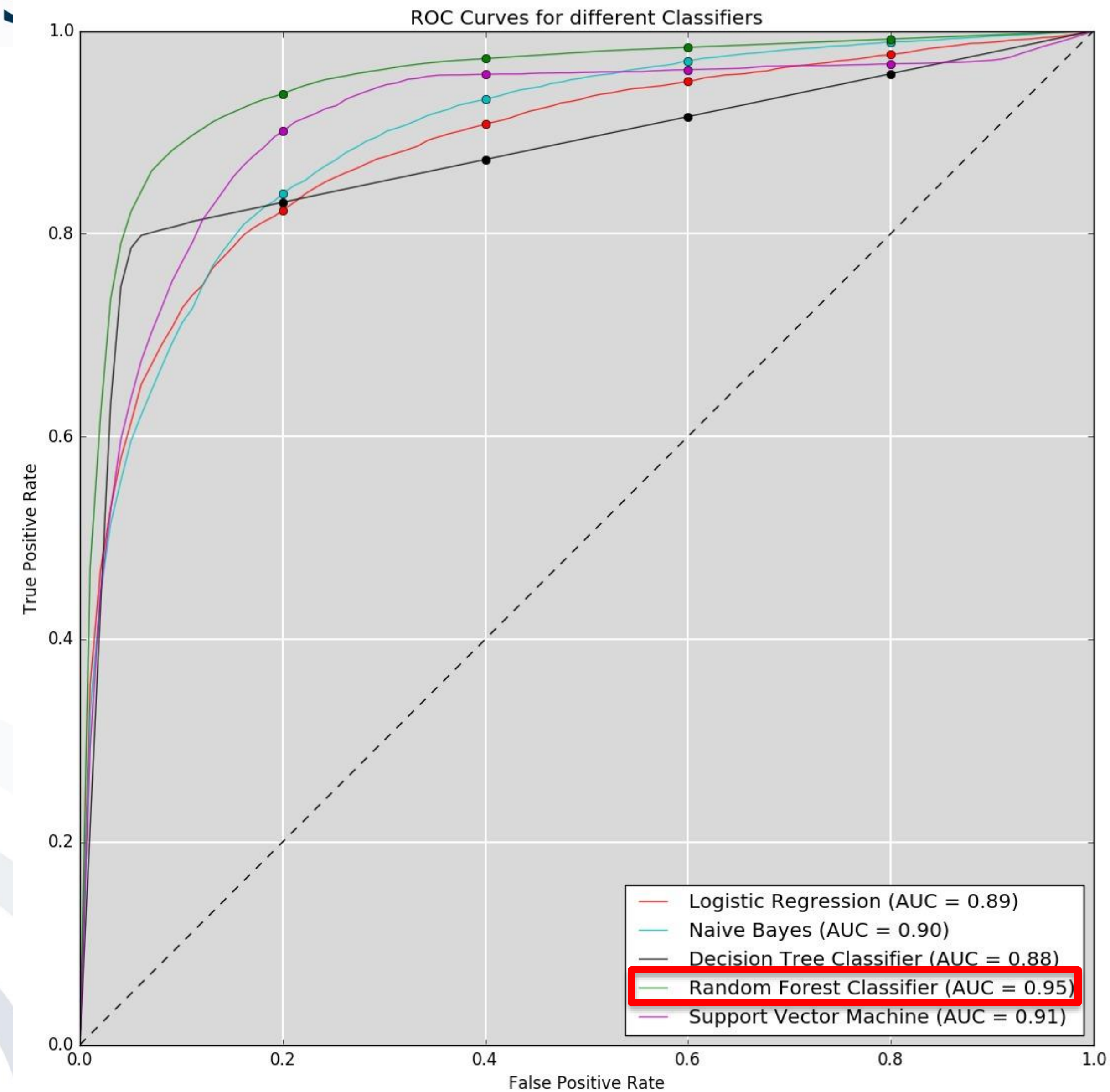


$$F(t) = \begin{cases} 1 & \text{if tweet is privacy sensitive} \\ 0 & \text{otherwise,} \end{cases}$$

where F is the prediction function we want to learn.

[Tesfay 2019]

Model I – PSI Detection



[Tesfay 2019]

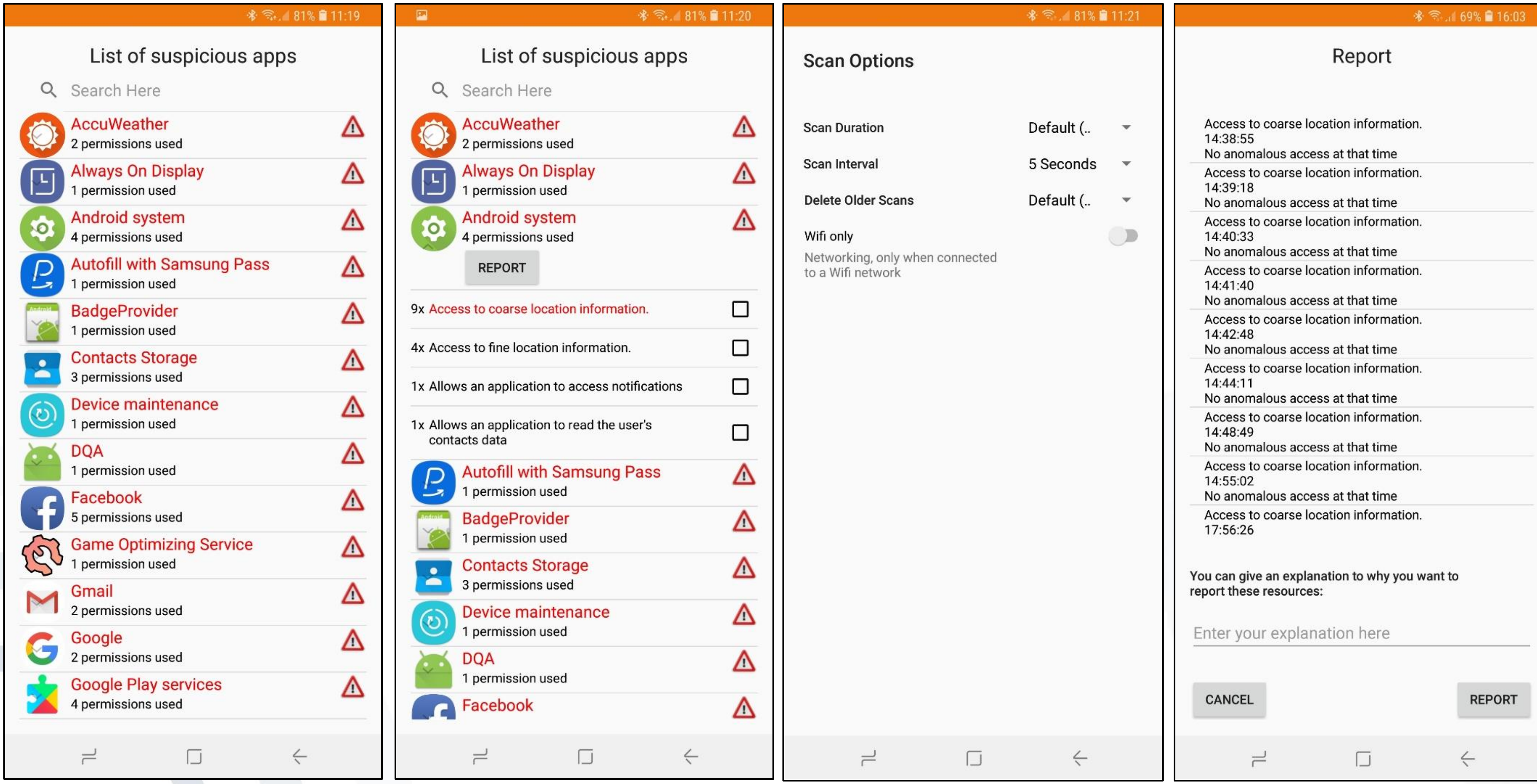
Android App Behaviour Analyser (A3) – Introduction

1 ❯ 2 ❯ 3

1. Responsible for monitoring apps' behaviour
2. Analysing potential privacy risks
3. Risk communication to users

[Hatamian2017]

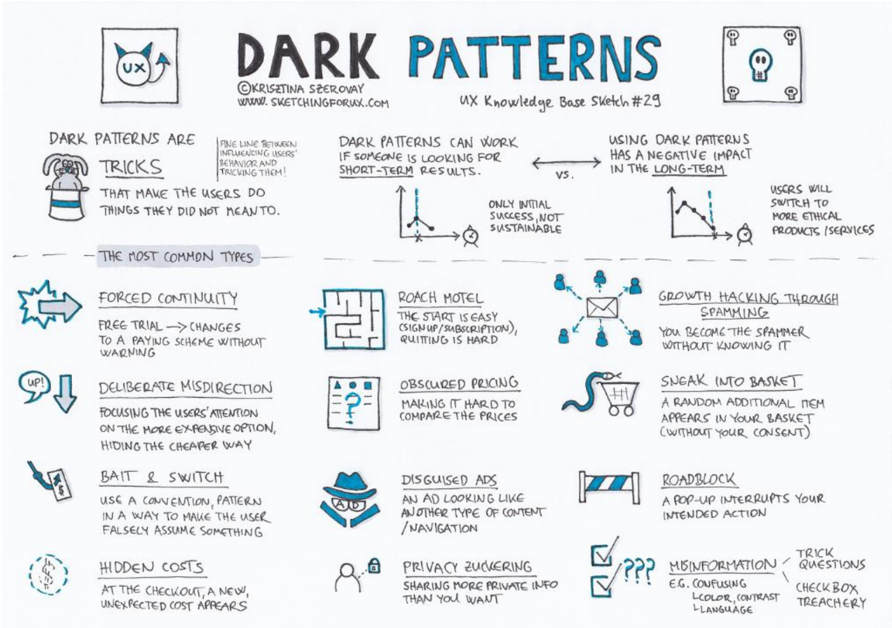
Android App Behaviour Analyser (A3) – User Interfaces

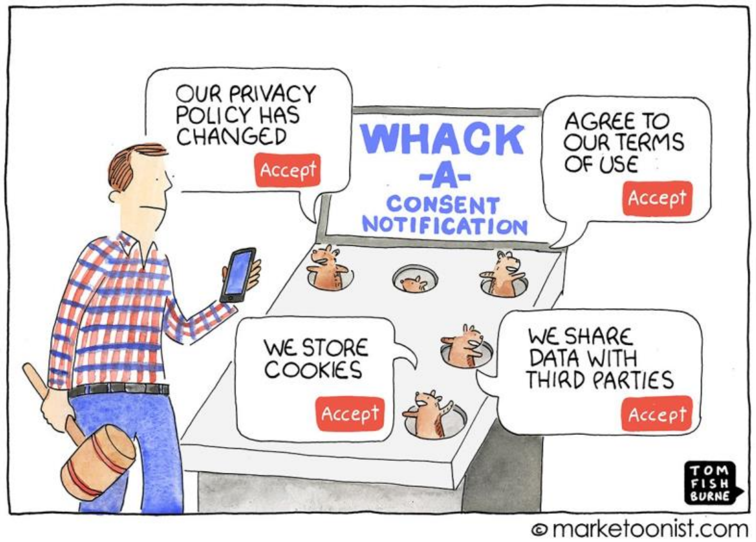


[Hatamian2017]

Privacy Challenges in HCI

- **Dark patterns** in UI to manipulate user choices
- **Consent fatigue** due to frequent permissions
- **User profiling risks** from behavioural data





[Bösch et al.2016] [Acquisti et al.2015]

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