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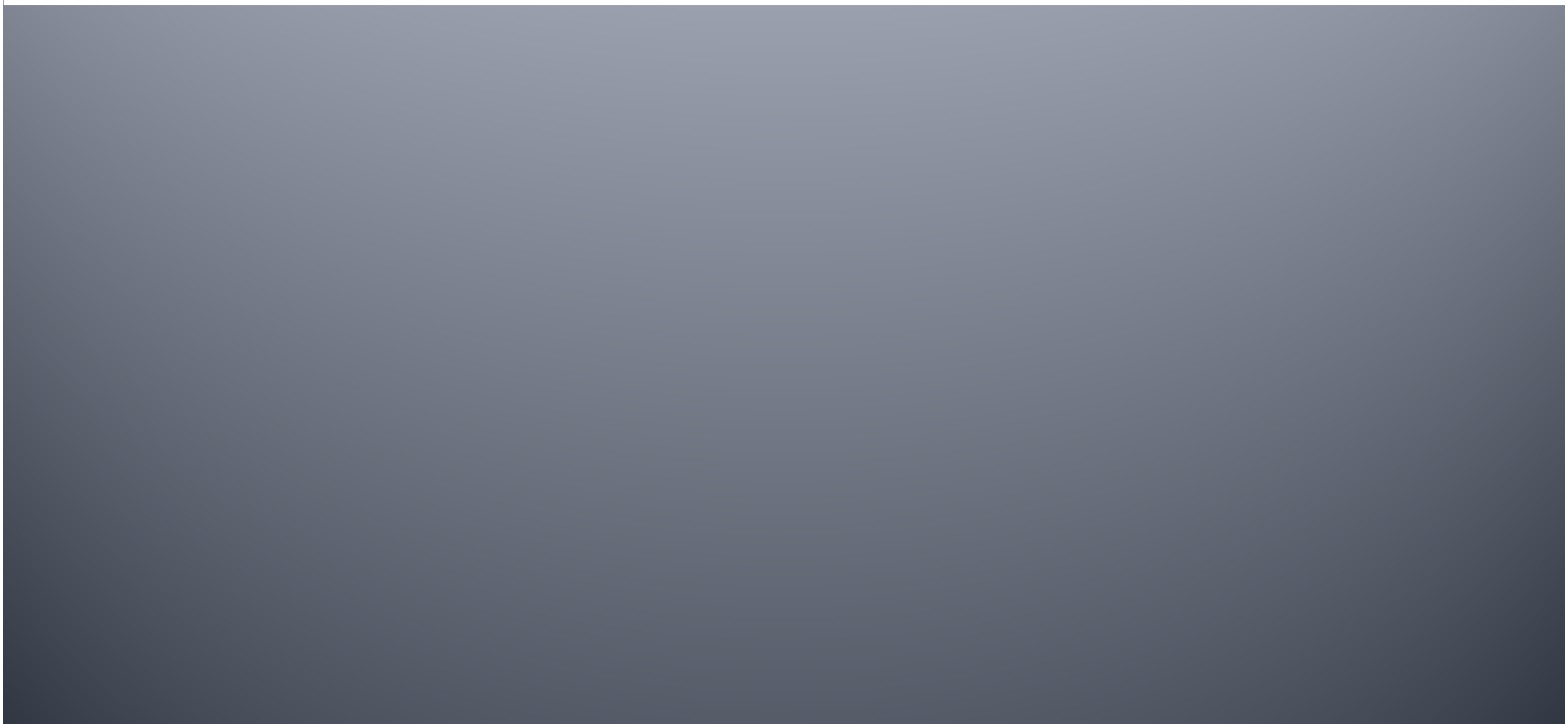
Evaluation of Context-aware Recommender Engines that Suggest Mobile Applications

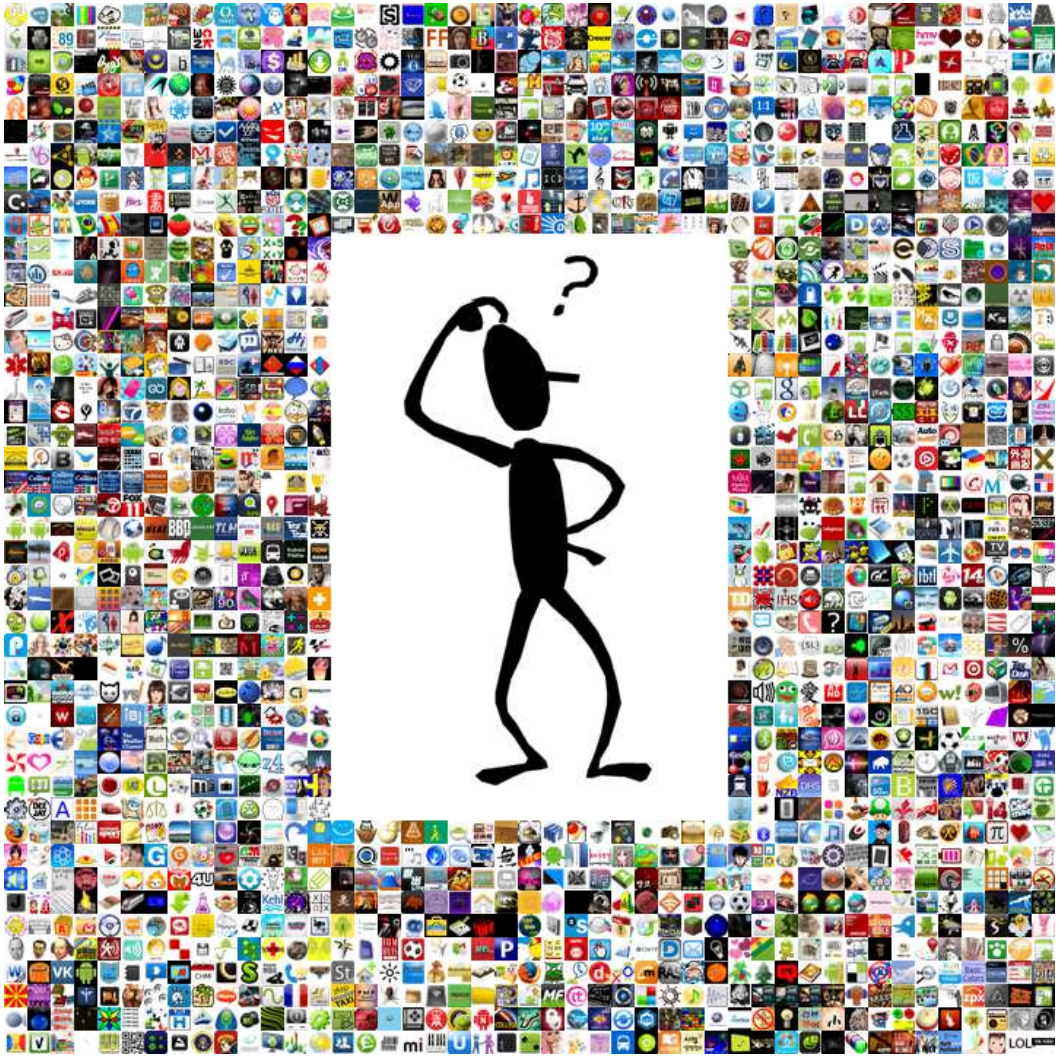
Outline

- Motivation
- Introduction
- Related Work
- Research Status
- Implementation
- Evaluation

Motivation



Motivation



- Mobile apps is a huge market
  - > 280,000 apps in Android Market (Sep.2011)
  - > 500,000 apps in Apple App Store (Oct.2011)
- Useful and interesting apps = needle in a haystack

[1] Wikipedia. List of digital distribution platforms for mobile devices. http://tiny.cc/joirz, accessed on October 21, 2011.

Naive Approach

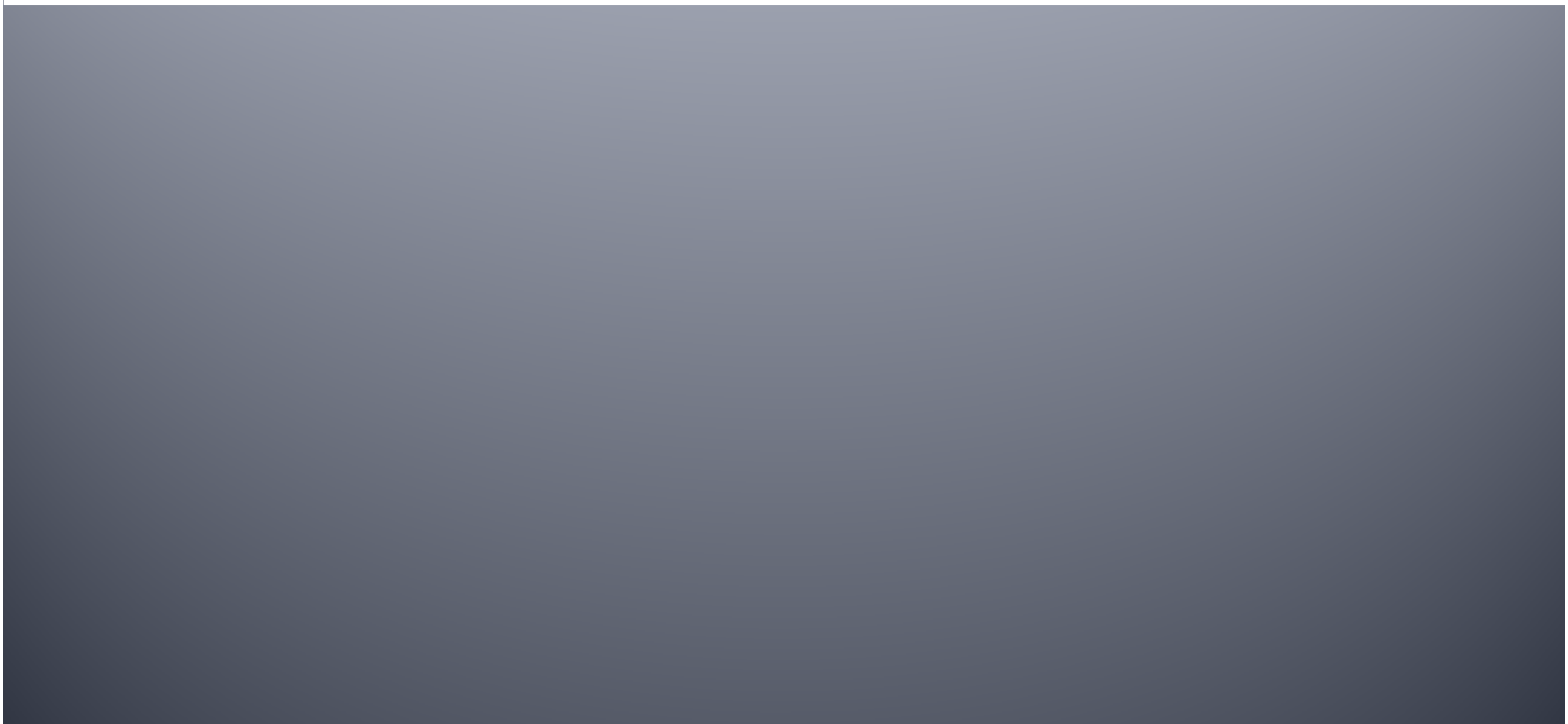
- Recommender systems that suggest mobile apps
  - Problem solved ? Not really!
  - *"Current systems that recommend mobile applications underachieve since they neglect the ever-changing context of their users and solely exploit sales figures and user ratings."*

[2] Böhmer, Bauer and Krüger. Exploring the Design Space of Context-aware Recommender Systems that Suggest Mobile Applications. In Proc. of Workshop CARS '10 (2010).

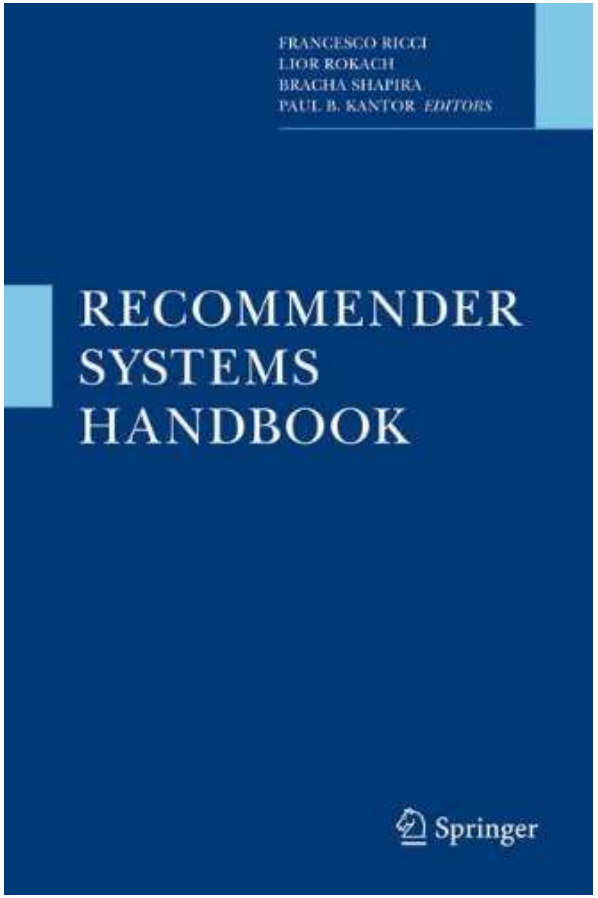
Problem Definition

- Mobile apps recommenders are still evolving
  - Different approaches for including context
- Specific evaluation approach is required
  - Following the lifecycle of mobile apps is important
- Goal: evaluate several recommendation engines inside a fully implemented mobile apps recommender system

Introduction



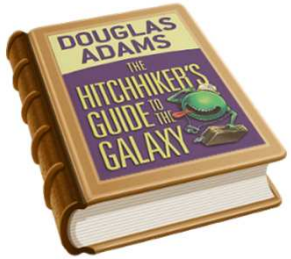
Recommender System Basics



- What is a Recommender System ?
  - *"Recommender Systems (RSs) are software tools and techniques providing suggestions for items to be of use to a user."*
- How does it work?
  - To identify the useful items for the user, a RS must be able to predict the utility of some items, or at least compare their utility, and then decide what items to recommend based on this comparison.

[3] Ricci, Rokach, Shapira and Kantor. Recommender systems handbook. Springer 2011.

Recommendable Items



- What kind of items?
  - Movies
  - Books
  - Electronics
  - Mobile Apps
- Items properties
  - Complexity
  - Utility

Recommendation approaches

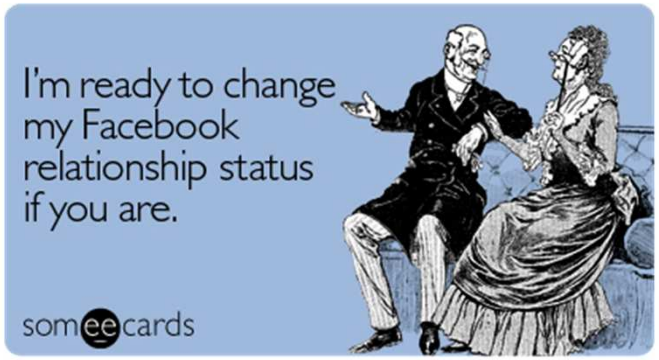
- Content-based – similar items based on item features
- Collaborative filtering – items which users with similar taste like
- Demographic – different demographic niches need different recommendations
- Knowledge-based – specific domain knowledge about how certain item features meet users needs
- Community-based – recommends items based on the preferences of the users friends
- Hybrid – combination of more than one approach

[3] Ricci, Rokach, Shapira and Kantor. Recommender systems handbook. Springer 2011.

Applications

- Entertainment – movies, music
- Content – news, documents, web pages
- E-commerce – consumer products to buy
- Services – travel, consulting, matchmaking

Context and Context-awareness



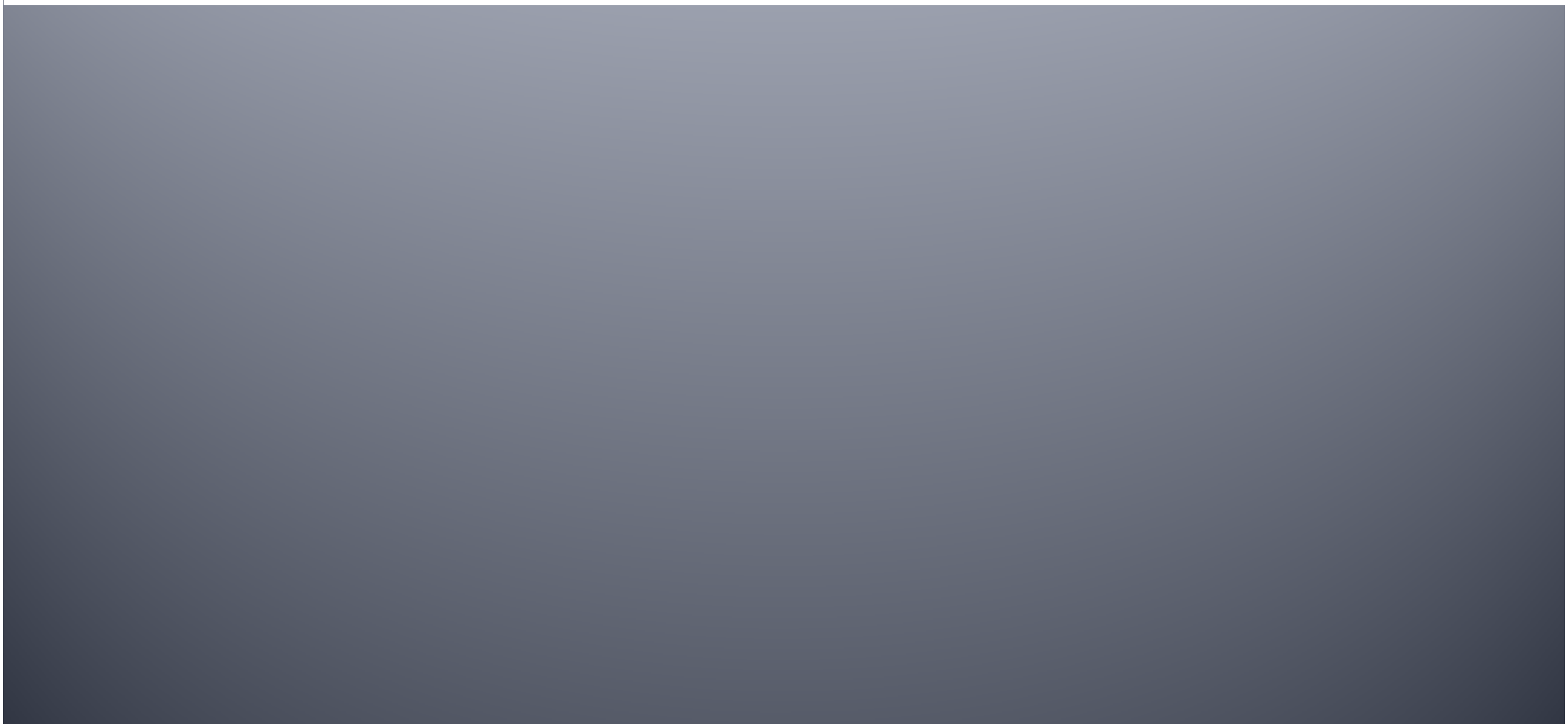
- Definitions:
  - *"Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves."*
  - *"A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task."*

[4] Dey. Understanding and Using Context. Personal Ubiquitous Computing, Vol. 5, No. 1. (20 January 2001), pp. 4-7.

Related Work

A Case Study on the Effectiveness of Recommendations in the Mobile Internet

Jannach and Hegelich (2009) [5]



Mobile Internet Recommendations

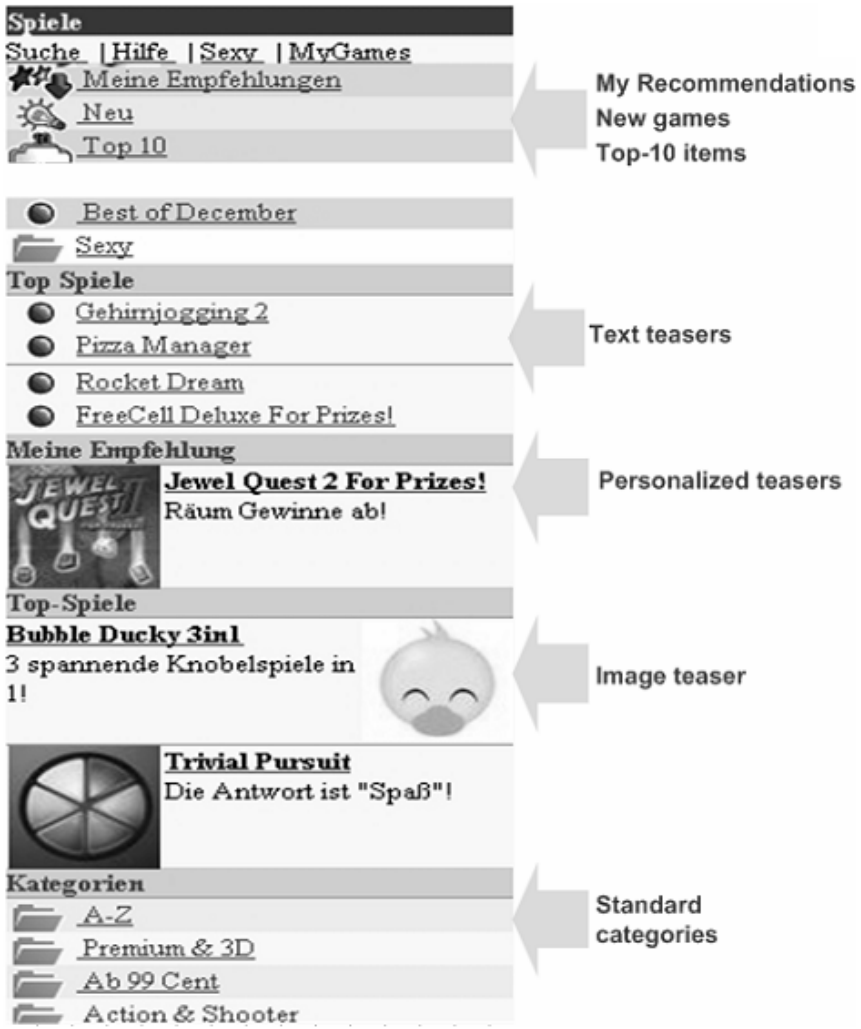


Fig 1. Layout of the website

- Study context:
  - A large-scale, commercial Mobile Internet platform for games
  - Sample of more than 155,000 different customers
  - 4 weeks evaluation period
- Analysis results:
  - Personalized recommendations increase the number of viewed and sold items

Mobile Internet Recommendations

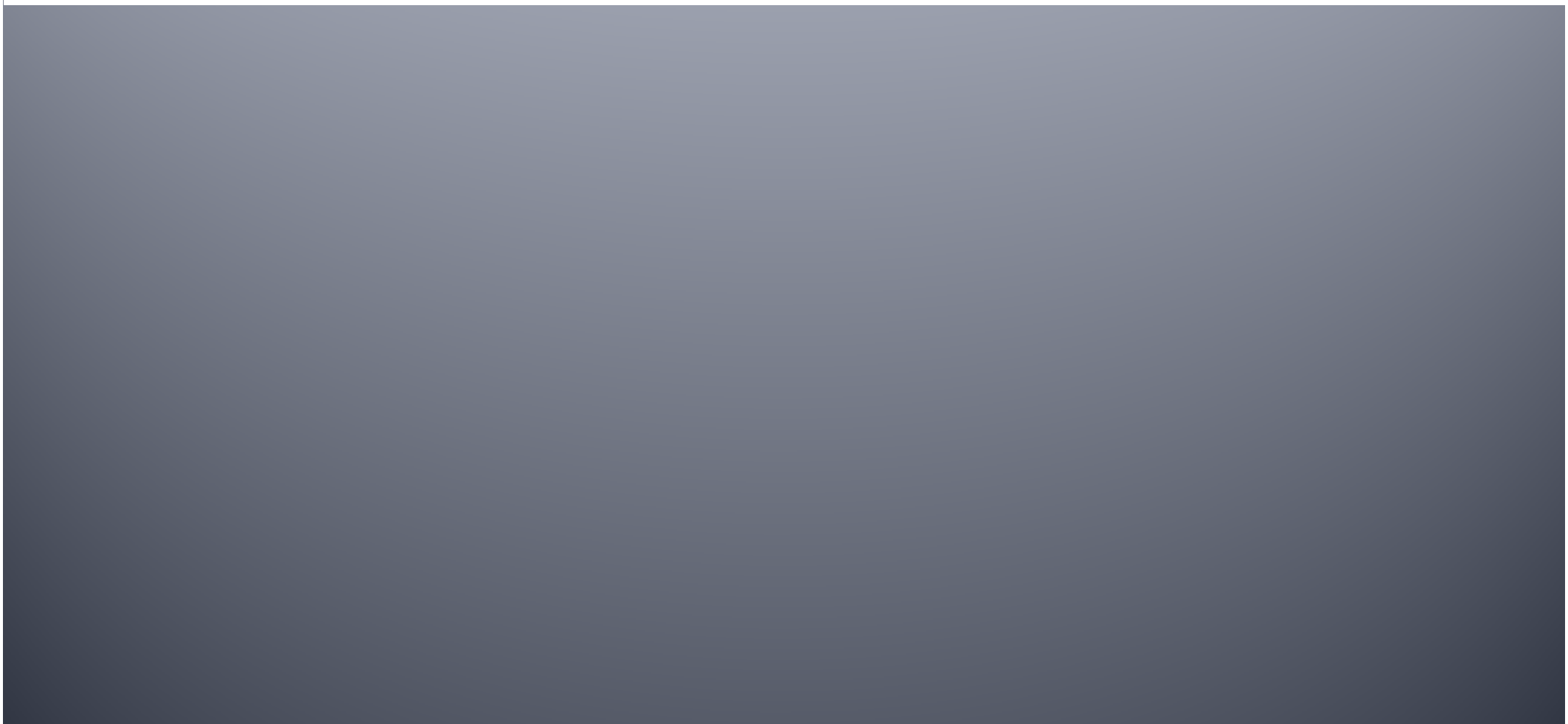
Method	Description
CF-Item	Item-based collaborative filtering
Content-Based	Item description and cosine similarity based
Hybrid	Combination of first two
SlopeOne	Item-based filtering
TopSeller	Ordering based on sales rank
TopRating	Average customer rating based ordering
Control	Manually-edited lists

Table 1. Description of groups

- Experimental setup
  - Participants divided in 7 groups on initial entering of the portal
  - Implicit customer ratings:
    - rating scale from -2 to +2
    - view = 0
    - purchase = 1
  - Explicit customer ratings, which override the implicit ones

An on-line Evaluation Framework for Recommender Systems

Hayes, Massa, Avesani and Cunningham (2002) [6]



On-line Evaluation Framework

- A comparative measure of how one recommendation strategy performs against another
- Problems with existing approaches
  - People tend to show variance when given the same test on two different occasions
  - Domain specific datasets used in many evaluation studies cannot be used to test every RS

On-line Evaluation Framework

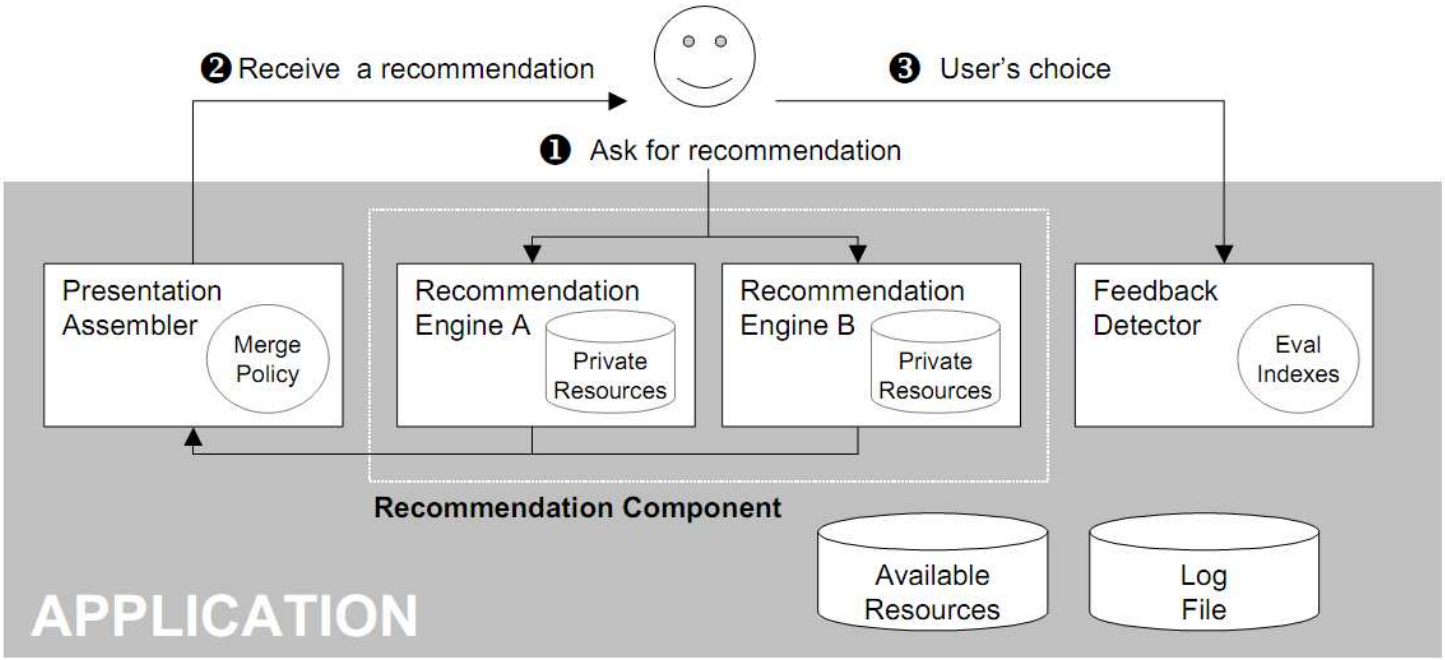


Fig 2.The framework architecture

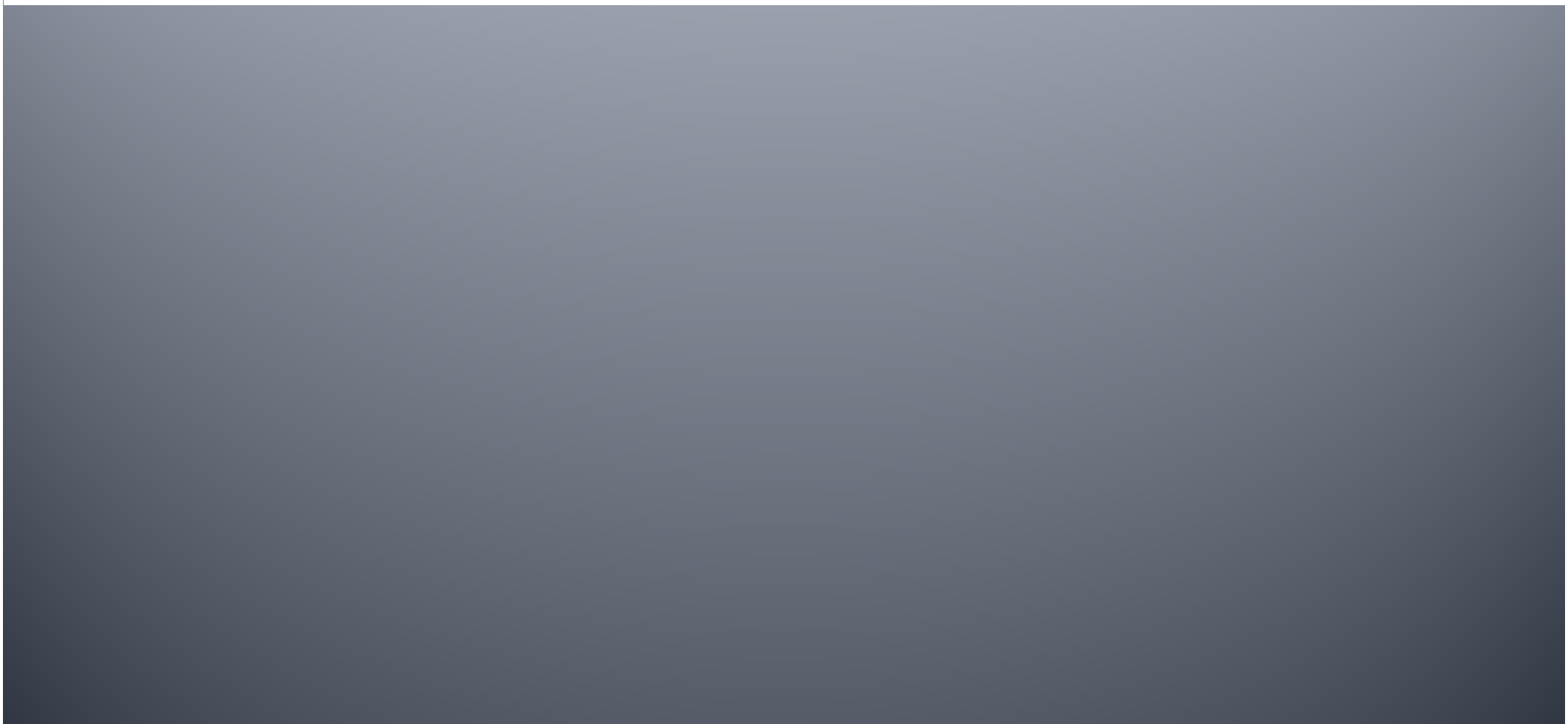
- Users are unaware of the source of recommendation
- Same conditions and same resources
- Presentation policy – merged; contrasting; cascading
- Evaluation feedback – implicit; explicit

On-line Evaluation Framework

- Advantages
  - Evaluation does not suffer from changes in user community or conditions
  - Possibility to extend the framework with an API for integration third party RS
- Drawbacks
  - Fully realized system with users is needed
  - Real users may be less tolerant of recommender error

A Hybrid Recommender System for Context-aware Recommendation of Mobile Applications

Woerndl, Schueller and Wojtech (2007) [7]



Hybrid Recommender System

- Goal
  - Deal with the added complexity of context by applying a hybrid recommender system
- Evaluation
  - Limited user evaluation
    - only 7 users and 6 applications
  - No explicit ratings
    - Information stored when user starts an application
    - Users are able to dislike an application

Hybrid Recommender System

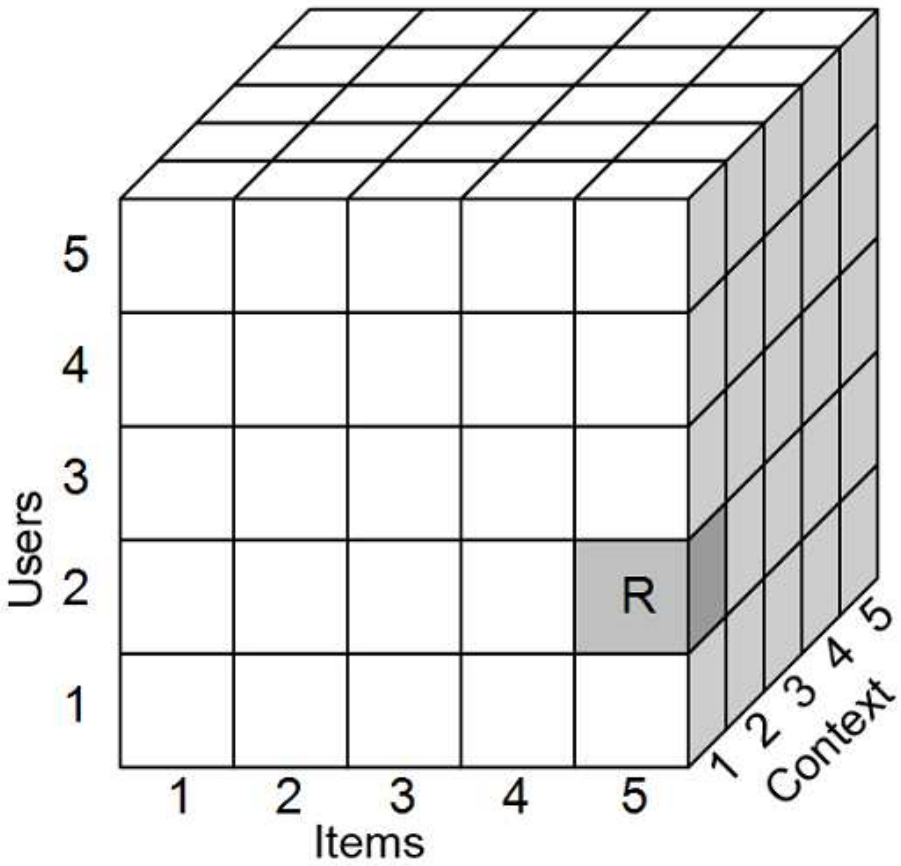
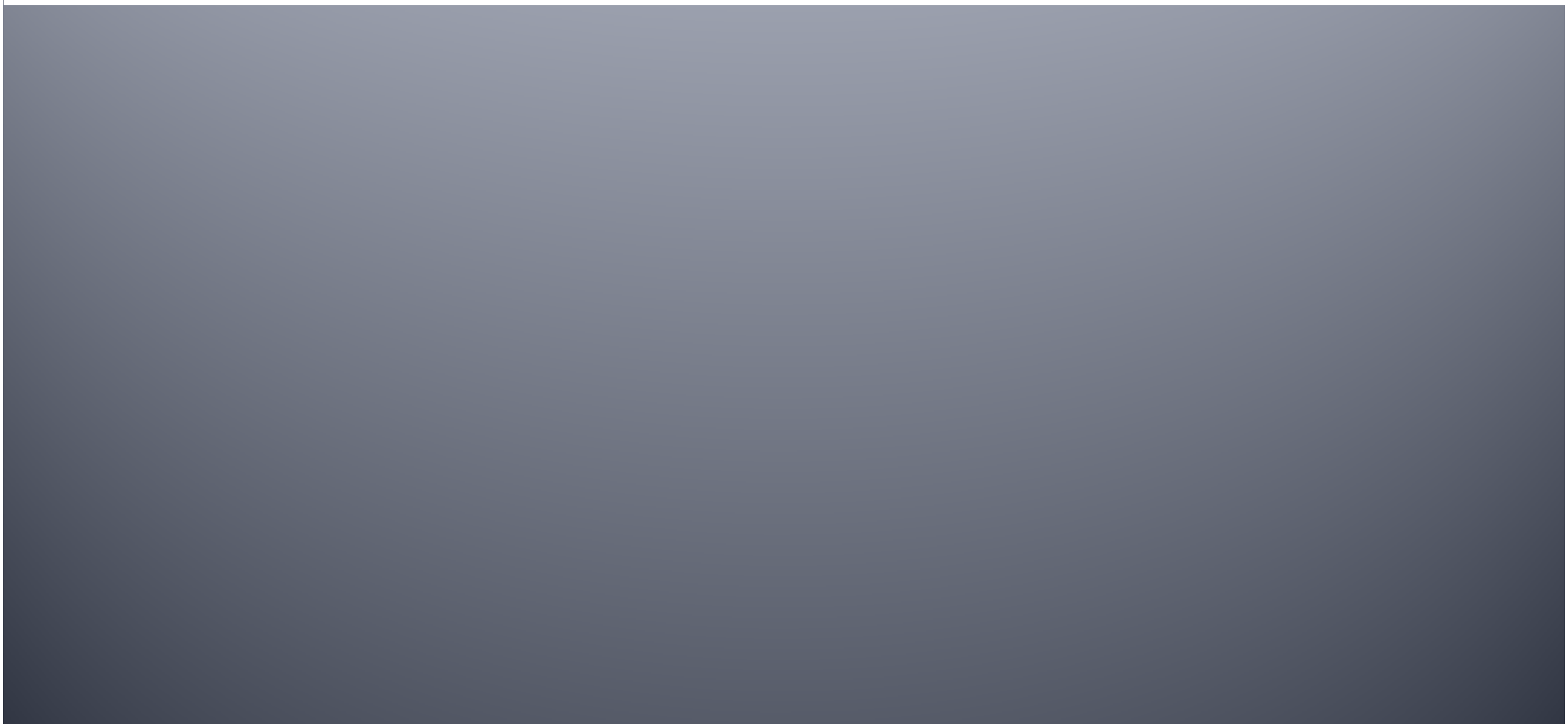


Fig 3.Integrating context in CF

- Cascading approach with 2 step recommendation
  - Content- or knowledge based filtering of relevant items based on context
  - Collaborative filtering to rank and additionally filter the result set
- Users could choose which recommender module to use

AppJoy: Personalized Mobile Application Discovery

Yan and Chen (2011) [8]



AppJoy

- Goal
  - Provide better personalized mobile application recommendations
- Motivation
  - User downloading an app is a weak indicator of whether the user likes that app
- Approach
  - Measuring real application usage and generate recommendations based on the usage scores

AppJoy

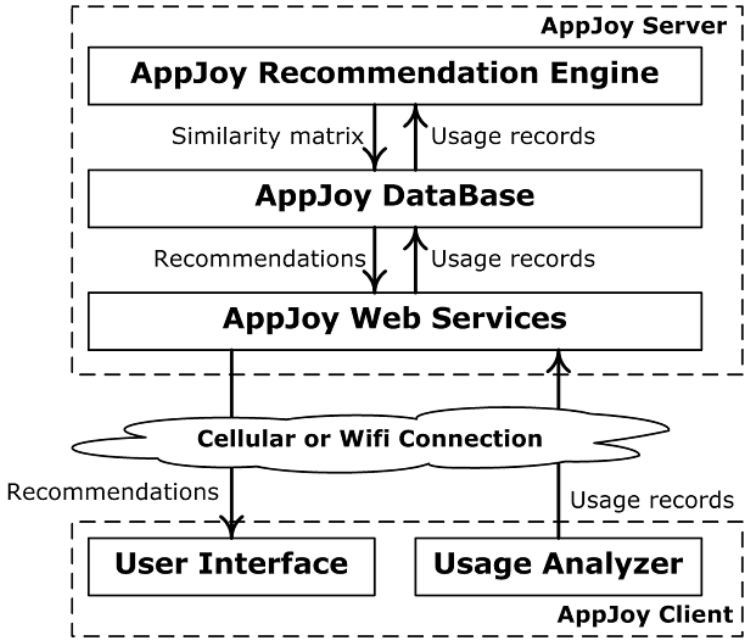


Fig 4.Architecture overview

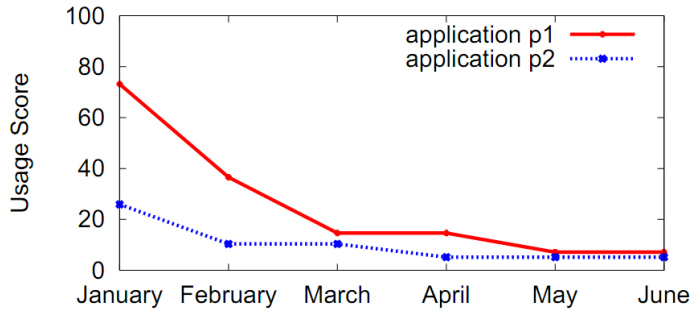


Fig 5. Usage score decreases over time once the apps are no longer used

- Client-Server architecture
- Assumption
  - The more an application is used suggests that the more the user likes it
- Usage score – RFD model
  - Recency – how recent
  - Frequency - how frequently for a time interval
  - Duration – how long

AppJoy

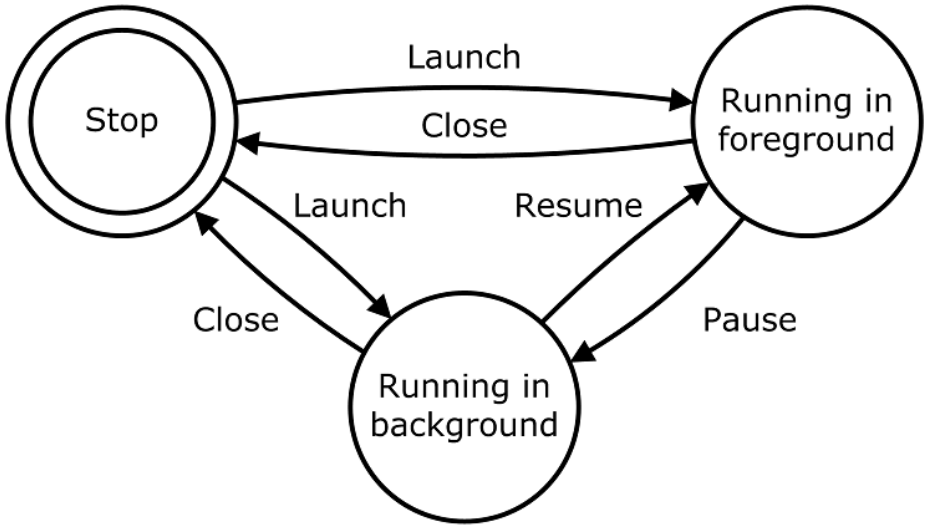


Fig 6.State transition of Android apps

- Automated data collection
- Application usage
  - Every second checking which application is in foreground
  - Application usage records containing the RFD model data
- User actions related to recommended apps
  - Recommended
  - Viewed
  - Installed
  - Rejected

AppJoy

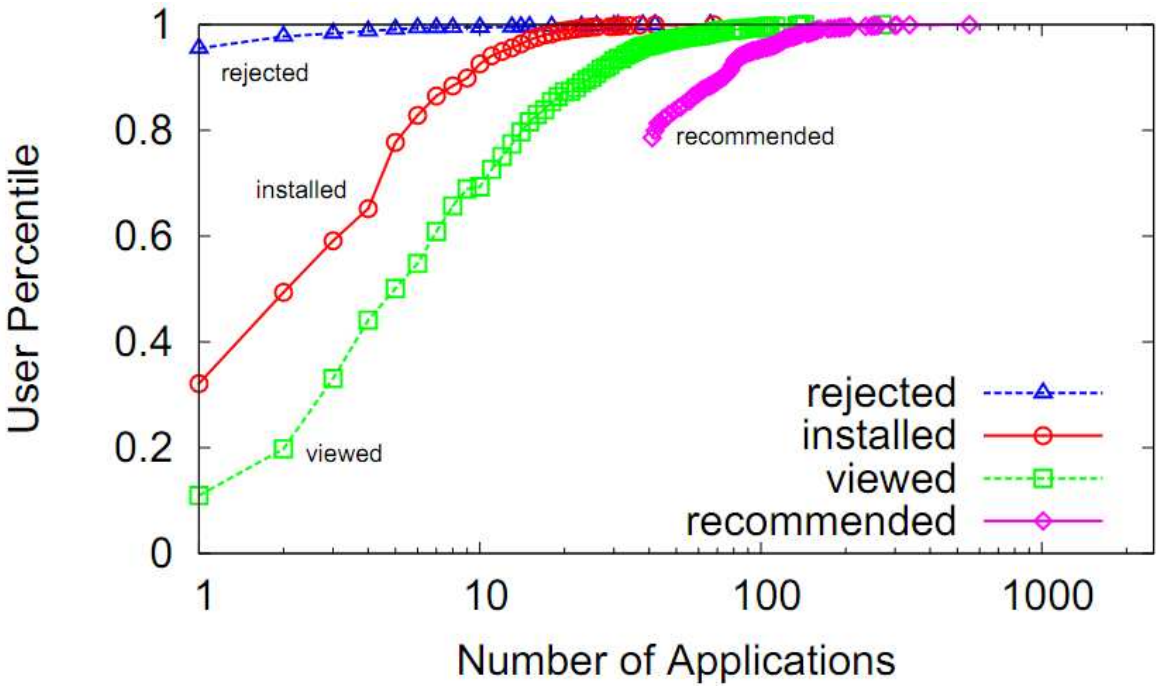


Fig 7. User actions statistic

- Evaluation characteristics
  - Fully implemented system
  - February 2010 – March 2011
- User actions
  - About 4.96% of all recommended apps were installed
  - Users tend to interact with the recommended apps longer

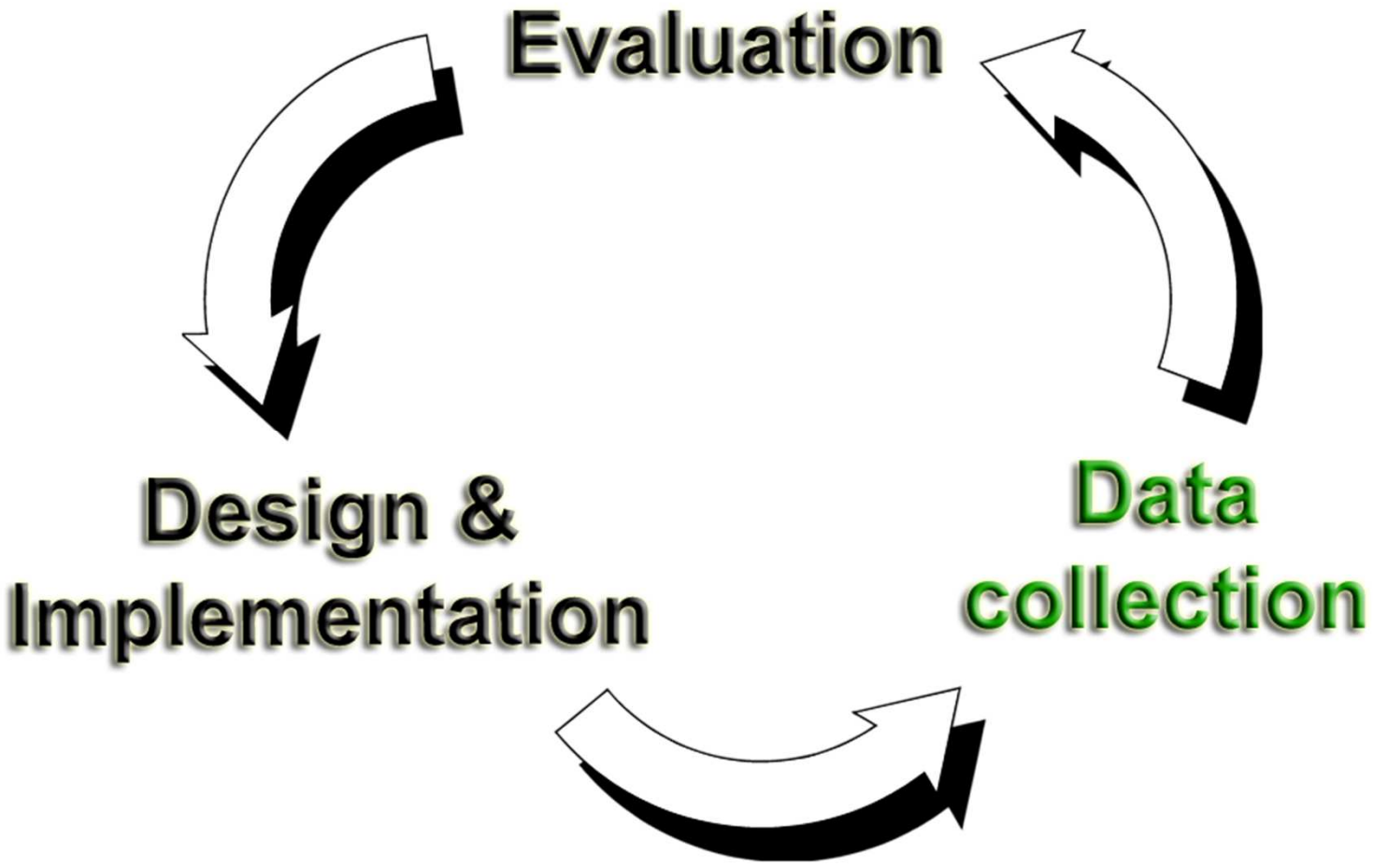
Contribution of my work

- Context-aware recommendation of mobile applications
- Fully implemented system with real users
- Monitoring of mobile application usage, user interactions and context entities
- Evaluation of several recommendation engines against each other

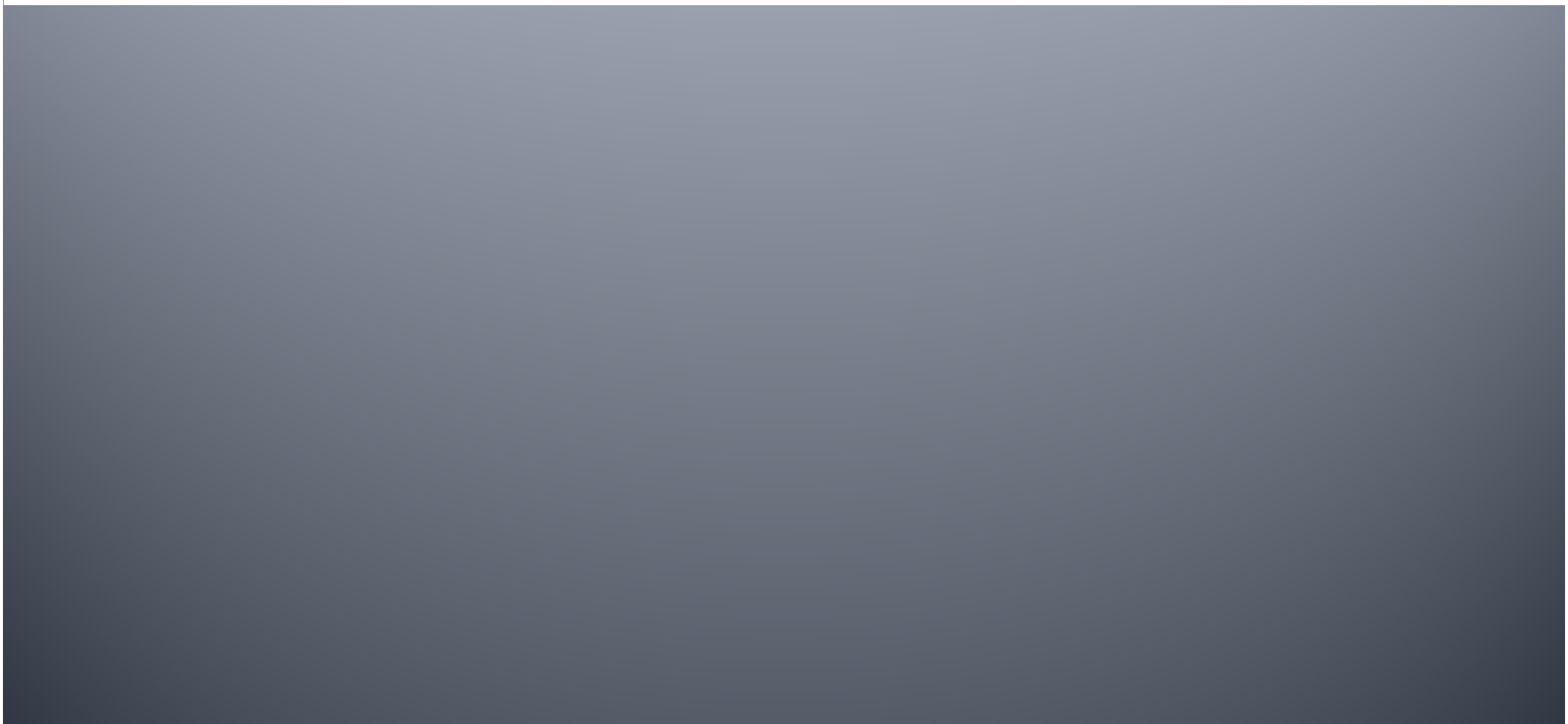
Research Status

Research Status

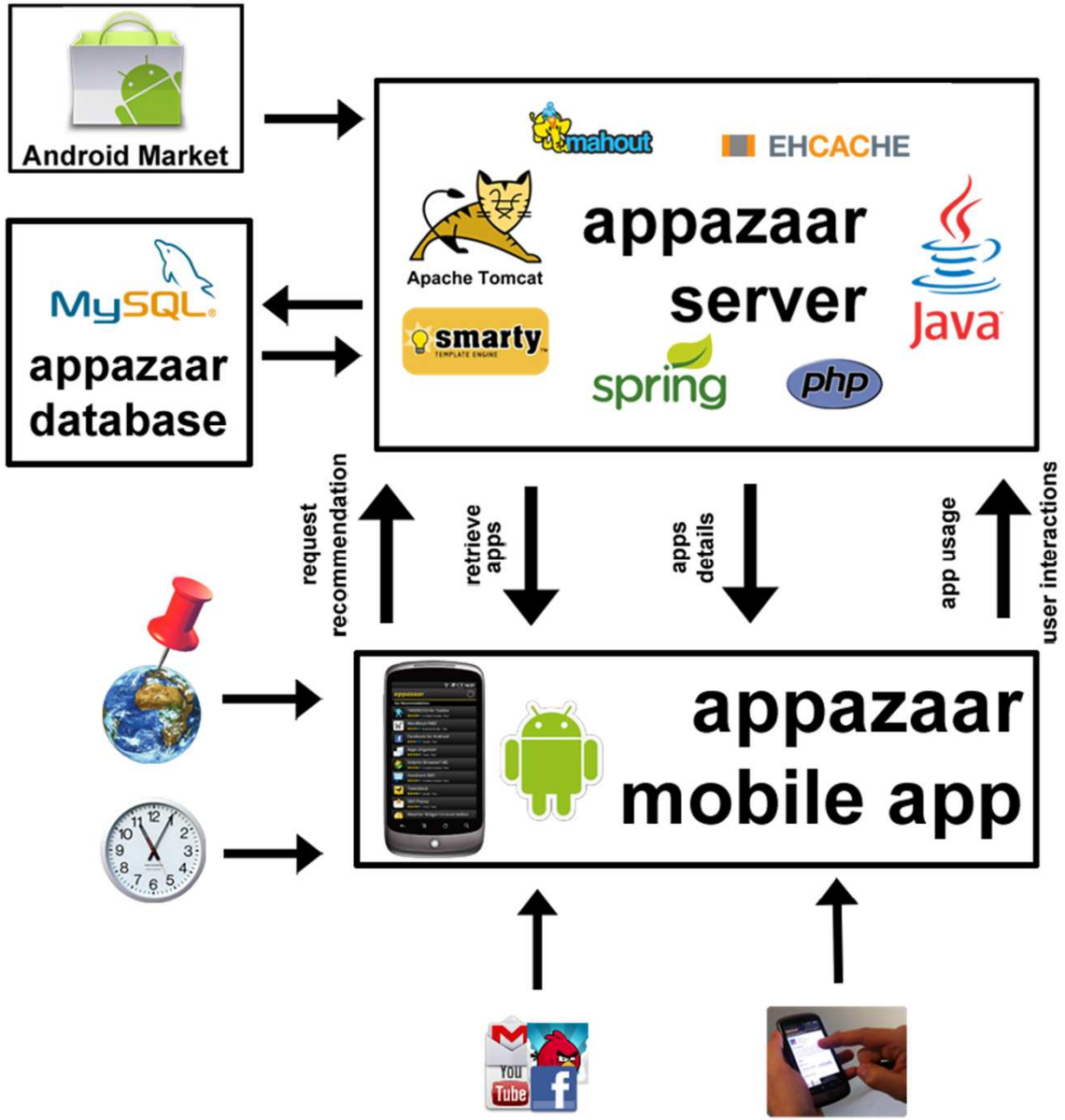
- The research is composed of 3 phases



Implementation



Implementation - Overview



- System architecture overview
  - appazaar server
    - Generate recommendations
    - Persist data from all devices
    - Maintain up to date apps details
  - appazaar mobile app
    - Present recommendations
    - Record various context entities
    - Record app usage data
    - Record user actions related to recommended apps

Implementation – appazaar Mobile App

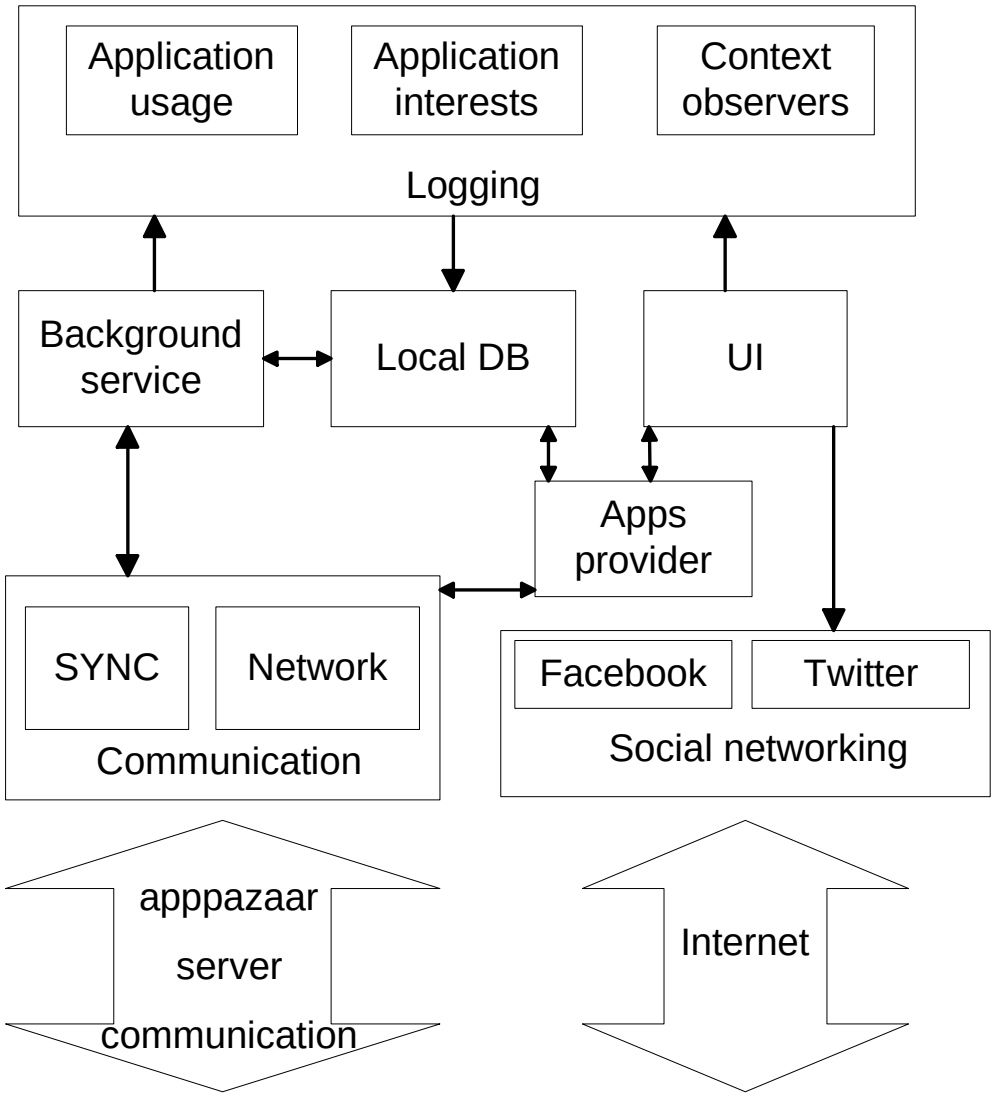


Fig 10. appazaar mobile app architecture

- Android app
  - Available to download in Android market
- Context entities
  - Device state – resolution, network state, model
  - Location – LON,LAT, UTC offset, country code
- App usage data
  - App lifecycle events
  - Data sampling rate 2Hz
- App interests
  - View, install, use recommended apps
  - Social networks sharing

Implementation – appazaar Server

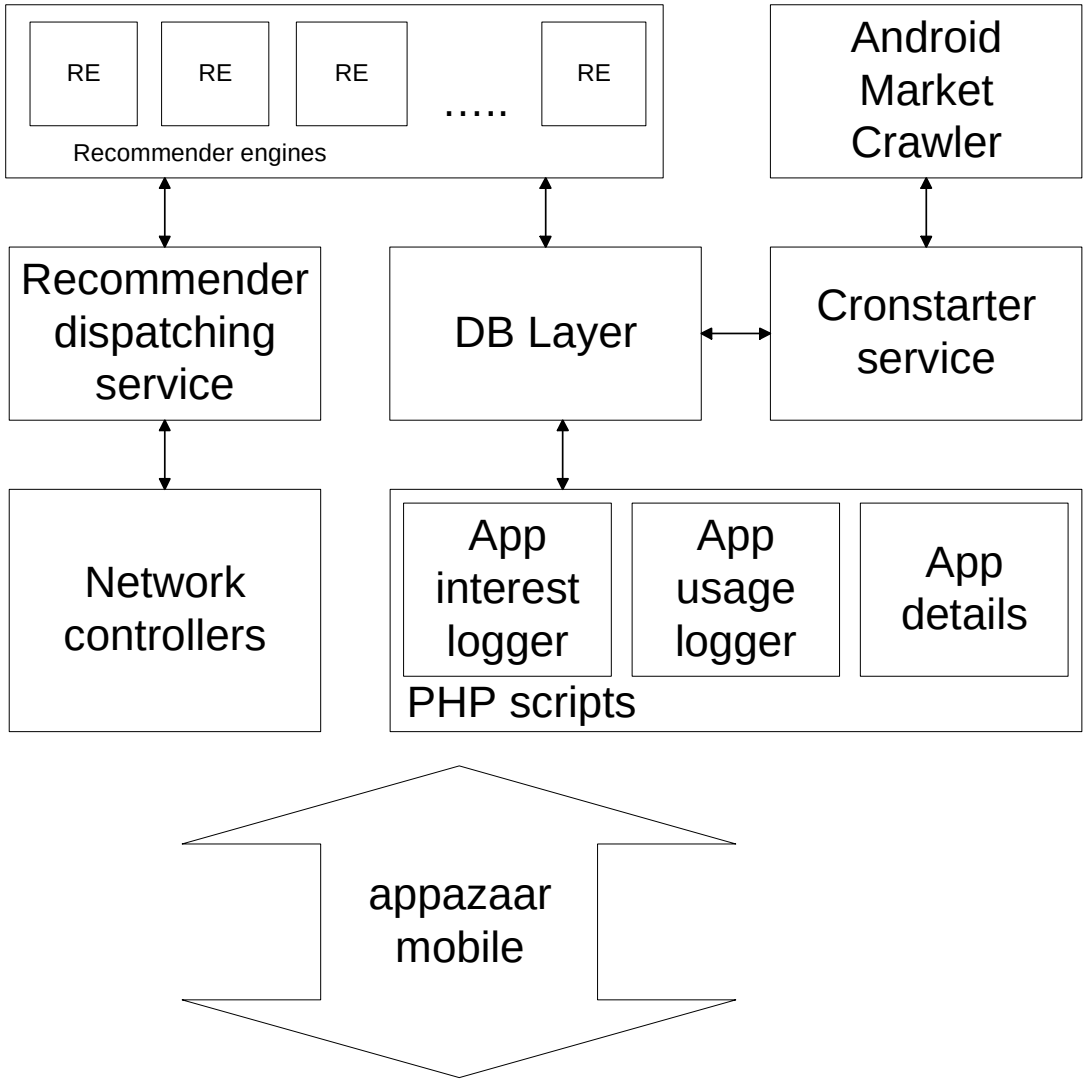


Fig 11. appazaar server architecture

- Android apps crawler
  - Crawl the market for app details, icons, etc.
- Random recommender engine dispatcher
- PHP scripts
  - logging of data coming from clients
  - application details in web pages
- Single database containing all data

Evaluation

Evaluation – Recommender Engines

	Non-personalized	Personalized
Non-contextualized	Most used apps Top rated apps Random apps	Usage based collaborative filtering
Contextualized	Running apps based	Location-aware usage collaborative filtering Time of day aware usage collaborative filtering

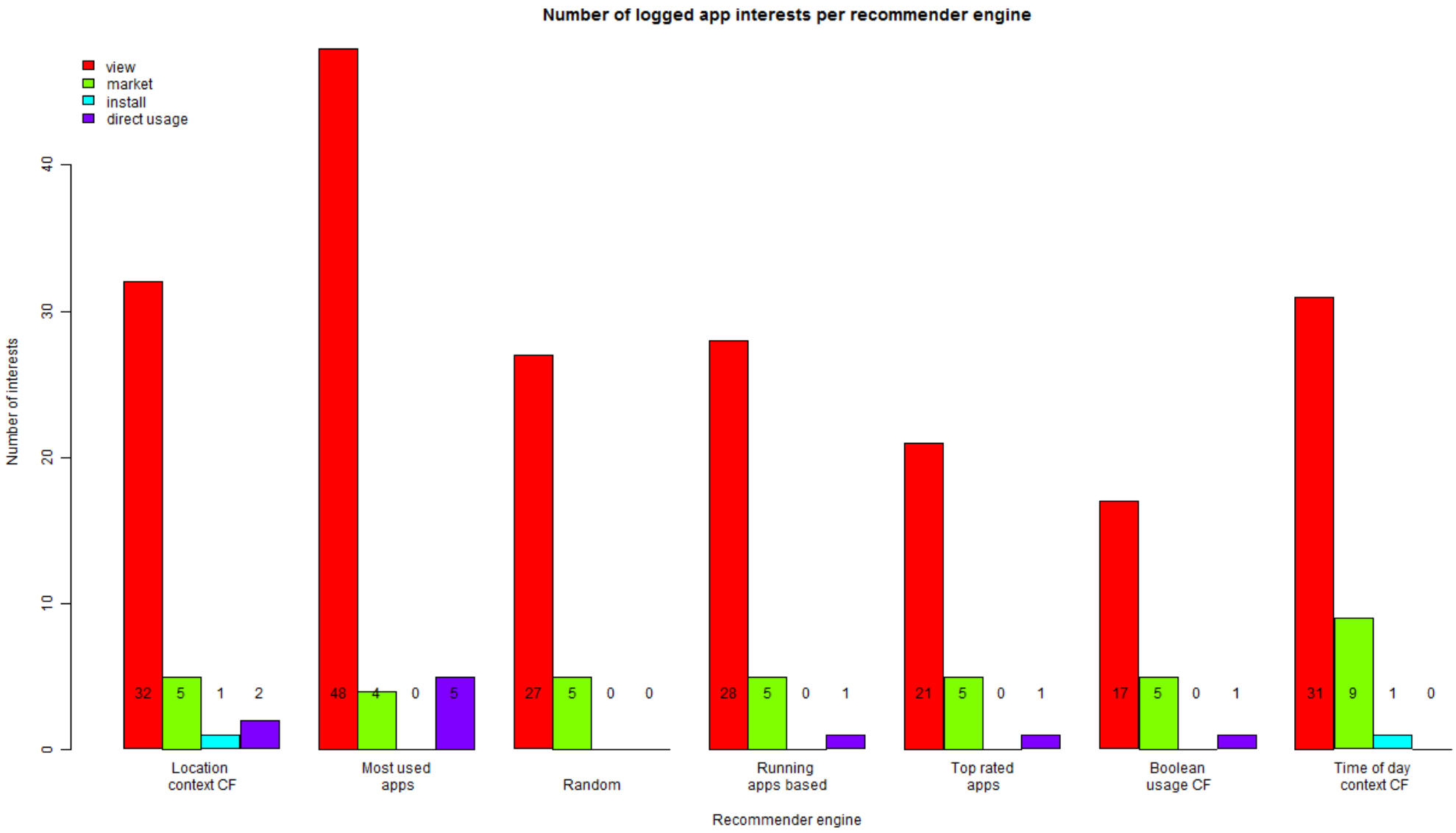
Table 2. Categorization of recommender engines

Evaluation – App Interest Model

- Metric – usefulness of recommendation
- Assumption – the more apps from a recommendation are installed and used, the more useful it is
- App interest model – chain of events caused by user interaction with recommended apps
- Every interest model is related to a particular recommendation

Fig 12. Chain of events in the application interest model

Evaluation – Example



Thank you!

Questions

References

1. Wikipedia. List of digital distribution platforms for mobile devices. http://tiny.cc/j0irz, accessed on October 21, 2011.
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6. Hayes, Massa, Avesani and Cunningham. An on-line evaluation framework for recommender systems. In Proc. of Workshop on Personalization and Recommendation in E-Commerce Malaga (2002).
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8. Yan and Chen. AppJoy - Personalized Mobile Application Discovery. In Proc. of MobiSys ’11 (2011).