Contextual Model for Data Sharing in Smartphone Applications

(MSc by Research in Comp.Sci.)

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in requirement of Ph.D. interview for ADAPT / Trinity

Why I chose this topic?

- Highlight research capabilities
- Comprehensive knowledge
- I made this - it is my creation

Contextual Model for Data Sharing in **Smartphone Applications**

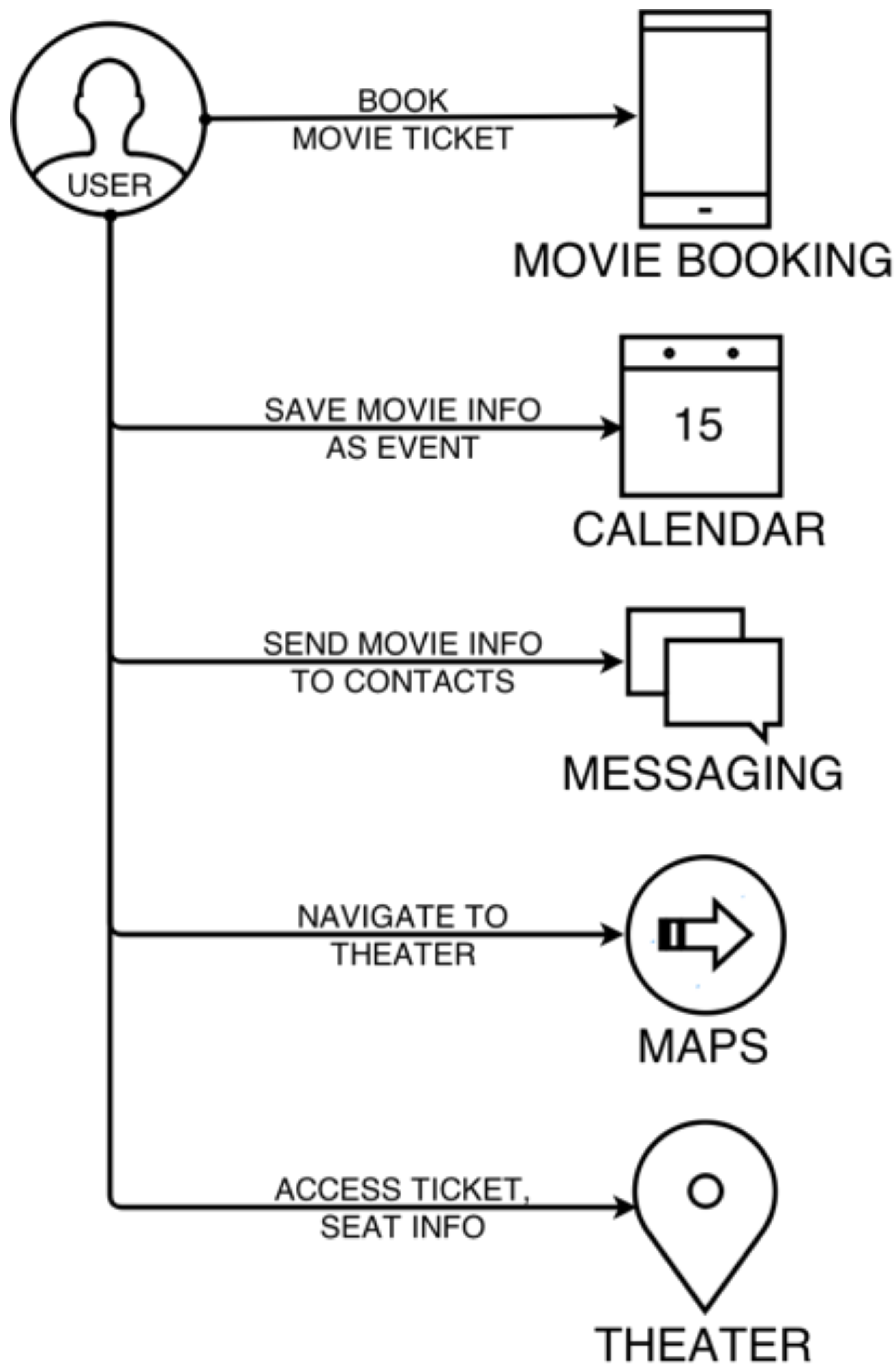
Problem Space

- Most personal device, always with us [1]
- New paradigm of computing and interfaces
- Everything available as *apps* [2]
- Less power, less storage, more things to do
- Increases efforts to do the same things as desktop / laptop computers

Contextual Model for **Data Sharing** in Smartphone Applications

Exchange of information in apps

- Different apps for different tasks, but same context
- Same information required / inputted
- When apps do not share contexts:
  - User must explicitly provide data
  - Enter text, select buttons or responses
  - Repeat instructions


USER
BOOK
MOVIE TICKET
MOVIE BOOKING
SAVE MOVIE INFO
AS EVENT
15
CALENDAR
SEND MOVIE INFO
TO CONTACTS
MESSAGING
NAVIGATE TO
THEATER
MAPS
ACCESS TICKET,
SEAT INFO
THEATER

Contextual Model for Data Sharing in Smartphone Applications

use contexts to better services

- Context matters - if app knows context, can target towards better services [3]
- Contextual services leverage limitation of device [4]
- Better features, more competitive, good for users

Breakdown

1. **Definition**: What is Context?
2. **Datastore**: How to store Context?
3. **Context Model**: How to use/share Context?

Context Definition

"*Context comprises of any information related to or affecting the users activities and tasks. This information includes time, location, weather, sensor information, and all information the user is presented with or enters on or related to a task.*" - formal definition, extended from Dey [5]

- Apps best know the context of their information
- Different apps have access to different information within the same context, but no means to consolidate the entire context or information
- To define context and its associated information, use schema

Context Schema

```
Event {
  Title
  Date/Time

  Location {
    GPS [x,y]
    Place
  }

  Contacts [] {
     Name
     Numbers []
     Address []
  }
}
```

A formal way to express contextual information

Embedded Contexts

```
Event {
  Title
  Date/Time

  Location {
    GPS [x,y]
    Place
  }

  Contacts [] {
     Name
     Numbers []
     Address []
  }
}
```

Location and Contacts are separate pieces of information, but related to Event

so *embed* them in the definition

Extended Contexts

```
Movie {
   Event* {…}

   Ticket {
      Ticket no
      Booking ref
      Seats []
   }

   Vouchers / Coupons {
      Voucher no
      Validity
   }
}
```

Extend the contextual information to represent different types of Events

Context Datastore

- Storage capacity limited on device
- Cloud storage expensive for sync and frequent operations
- Frequently used information must be cached

Therefore, some form of on-device storage necessary

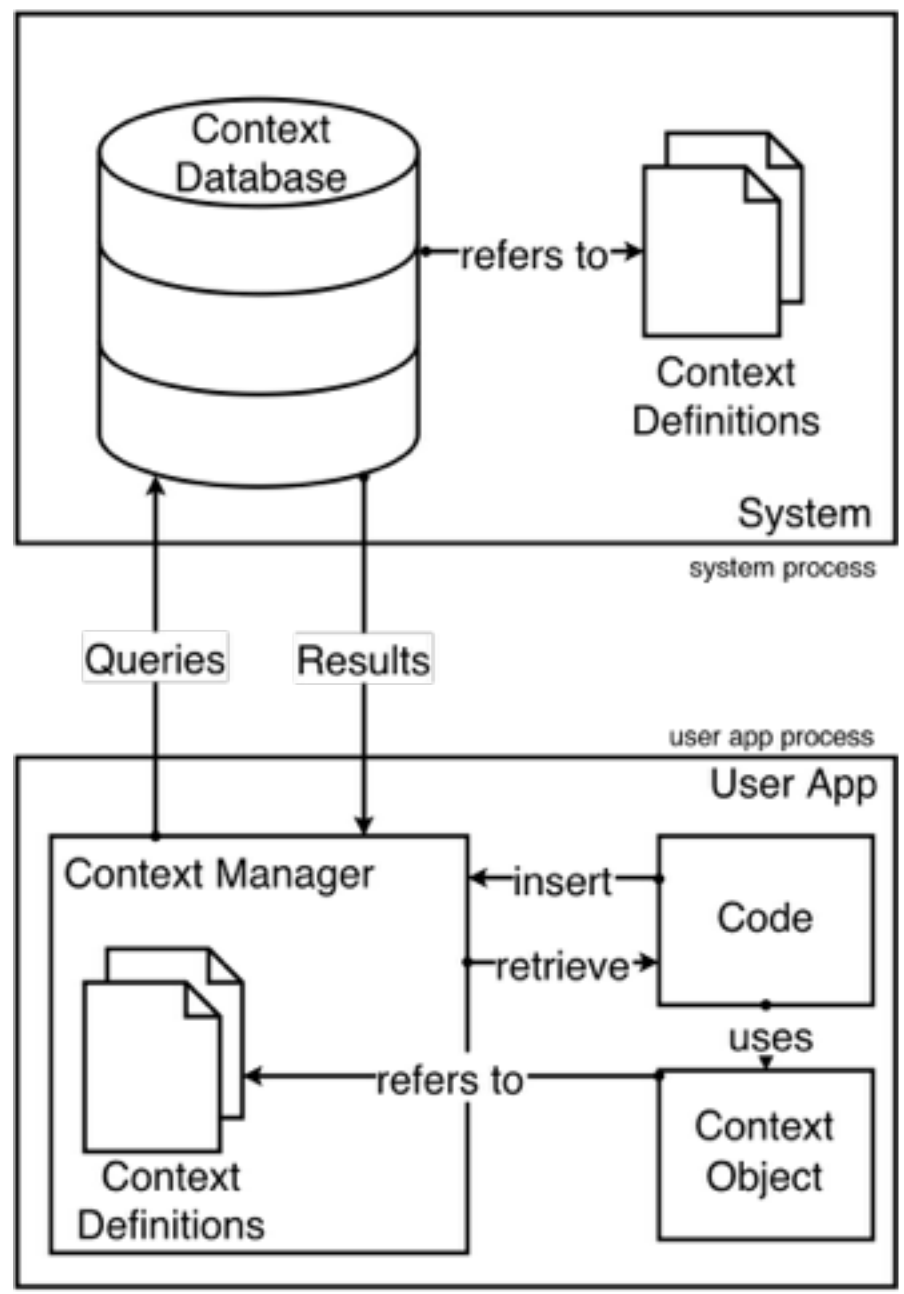
Context Datastore

- Responsible for managing and storing contextual information
- Keeps data even when app that created it is uninstalled
- Apps can share data via the context datastore

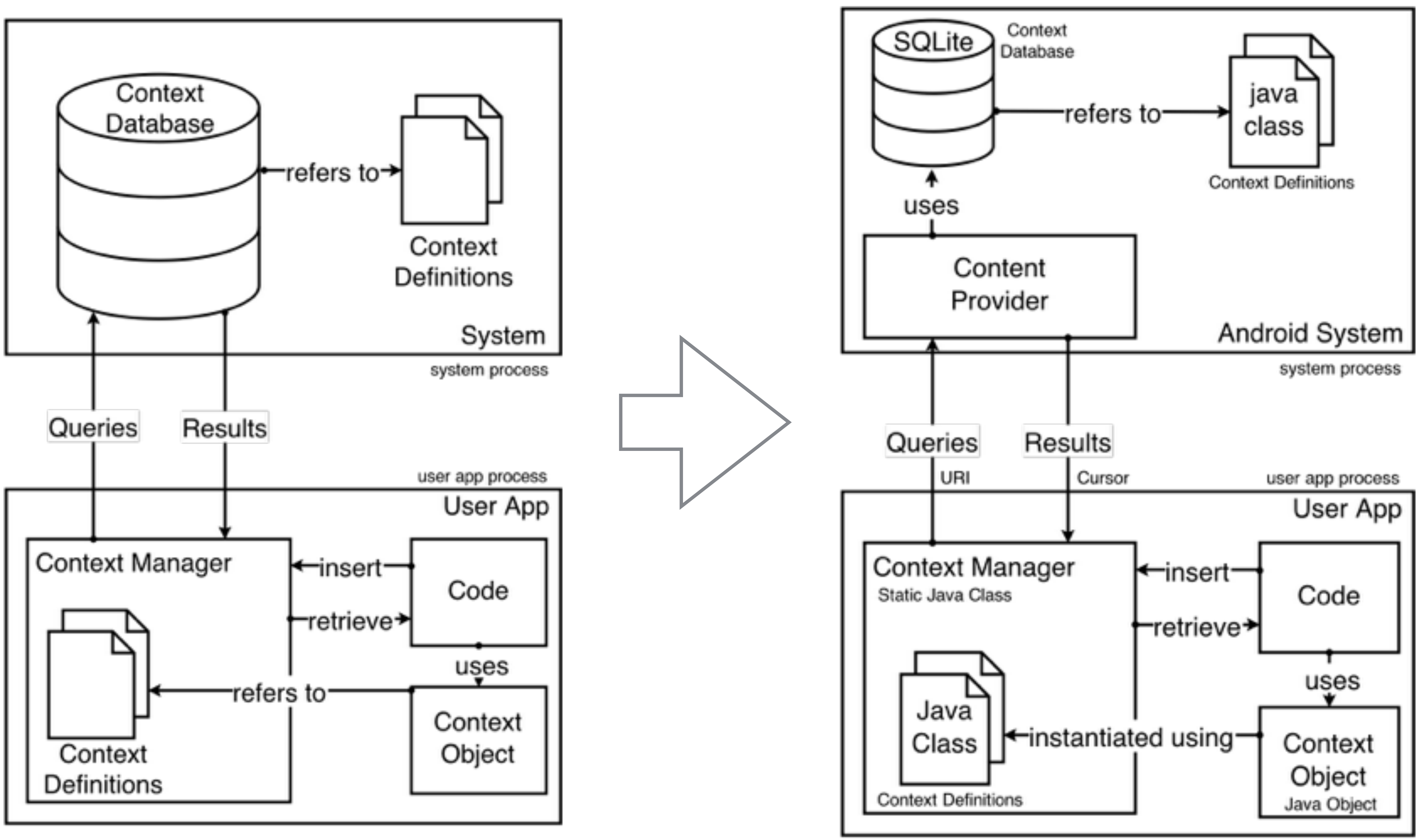
Context Datastore Performance

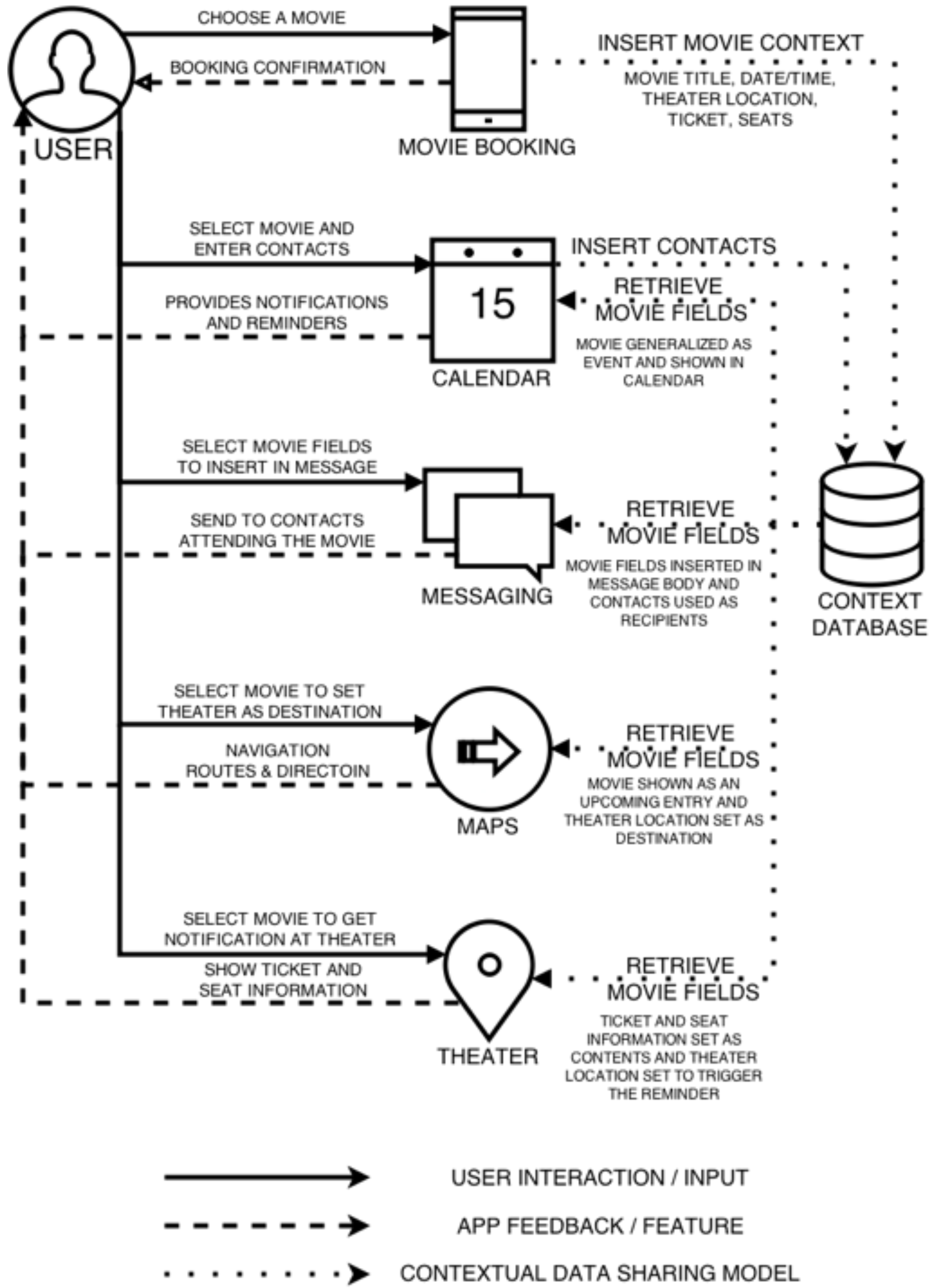
- Size affects performance of queries
- For security reasons, apps cannot directly interact with data (no explicit deletions)
- Deletion managed by **Deletion Policy**
    - **What** is to be deleted (data records)
    - **When** is it to be deleted (event that triggers deletion)
    - **How** to manage relations (embedded / extended)

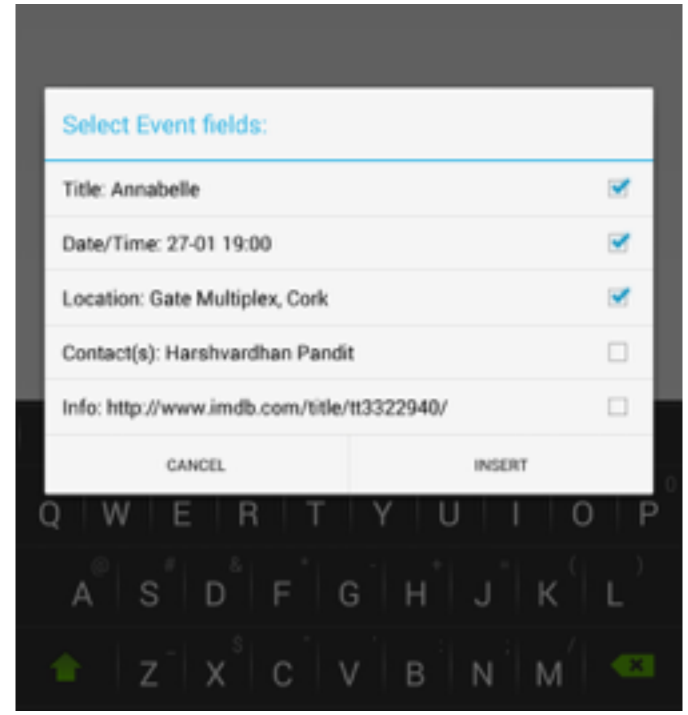
System Model



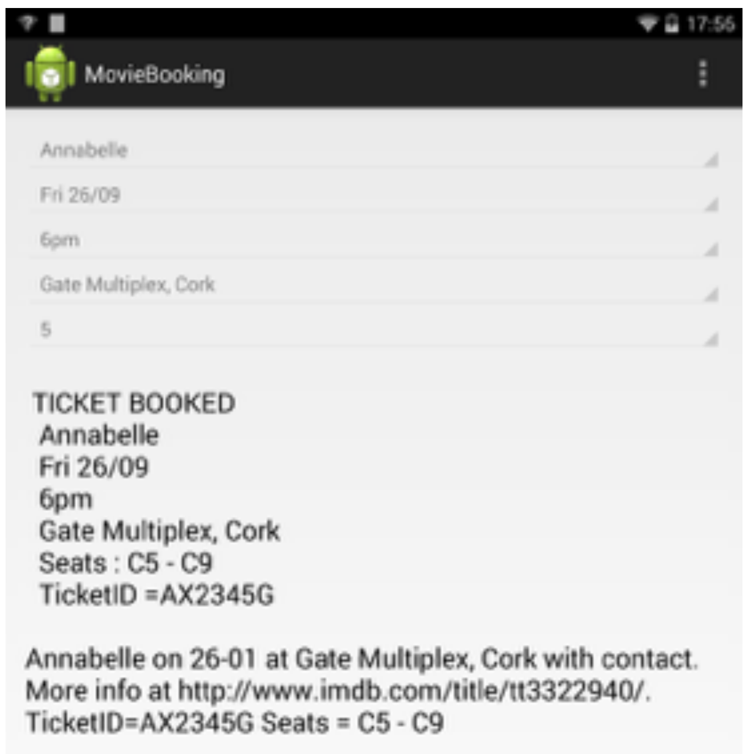
Implementation Model



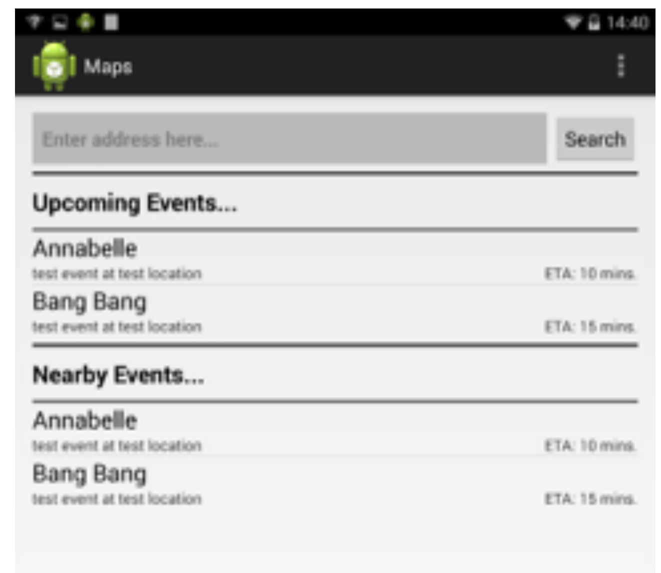

CHOOSE A MOVIE
BOOKING CONFIRMATION
USER
MOVIE BOOKING
INSERT MOVIE CONTEXT
MOVIE TITLE, DATE/TIME, THEATER LOCATION, TICKET, SEATS
SELECT MOVIE AND ENTER CONTACTS
PROVIDES NOTIFICATIONS AND REMINDERS
15
CALENDAR
INSERT CONTACTS
RETRIEVE MOVIE FIELDS
MOVIE GENERALIZED AS EVENT AND SHOWN IN CALENDAR
SELECT MOVIE FIELDS TO INSERT IN MESSAGE
SEND TO CONTACTS ATTENDING THE MOVIE
MESSAGING
RETRIEVE MOVIE FIELDS
MOVIE FIELDS INSERTED IN MESSAGE BODY AND CONTACTS USED AS RECIPIENTS
CONTEXT DATABASE
SELECT MOVIE TO SET THEATER AS DESTINATION
NAVIGATION ROUTES & DIRECTOIN
MAPS
RETRIEVE MOVIE FIELDS
MOVIE SHOWN AS AN UPCOMING ENTRY AND THEATER LOCATION SET AS DESTINATION
SELECT MOVIE TO GET NOTIFICATION AT THEATER
SHOW TICKET AND SEAT INFORMATION
THEATER
RETRIEVE MOVIE FIELDS
TICKET AND SEAT INFORMATION SET AS CONTENTS AND THEATER LOCATION SET TO TRIGGER THE REMINDER
USER INTERACTION / INPUT
APP FEEDBACK / FEATURE
CONTEXTUAL DATA SHARING MODEL



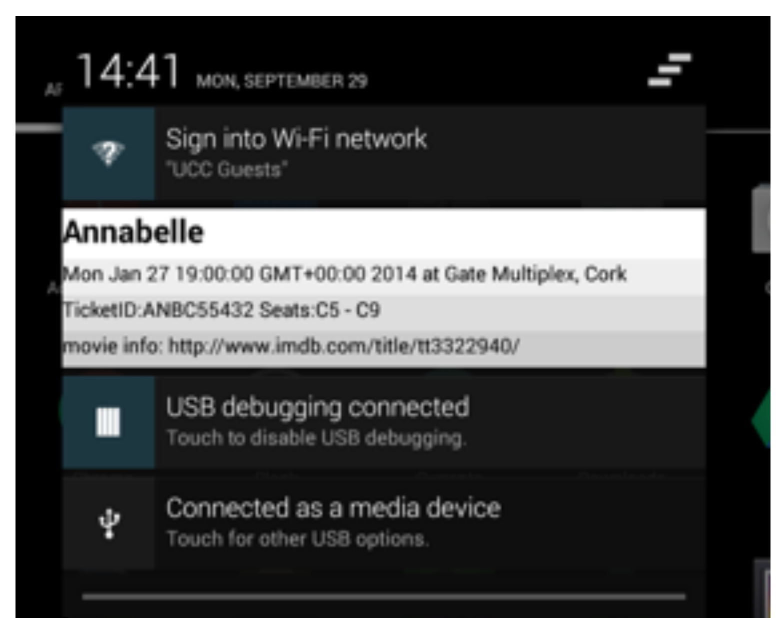
Messaging attendees



Ticket booking



Navigating to Event

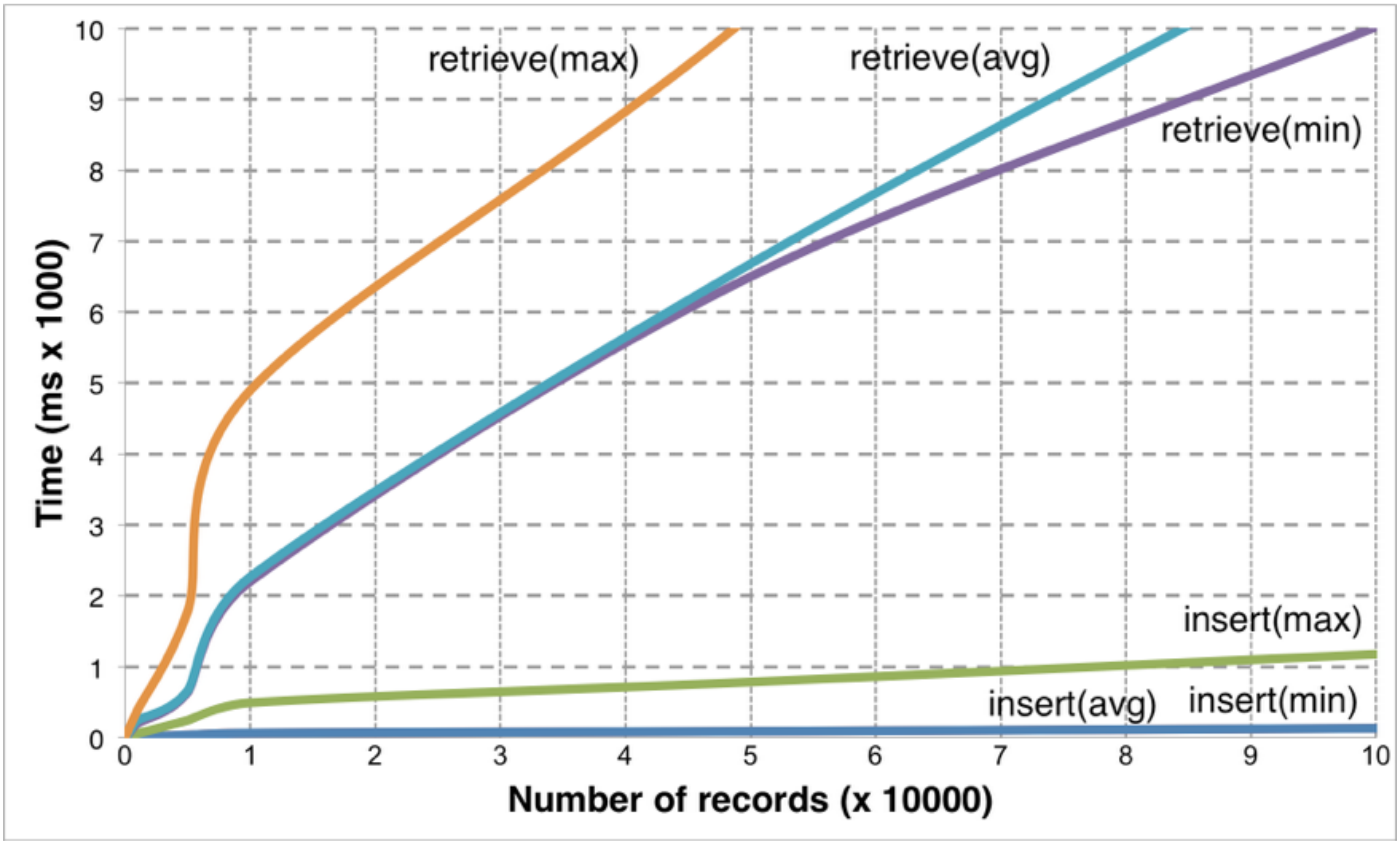


Notification at Location

Metrics and Testing

- Size of Database
- Speed of queries
- Impact on operation of other apps
- Impact of Usability of the device

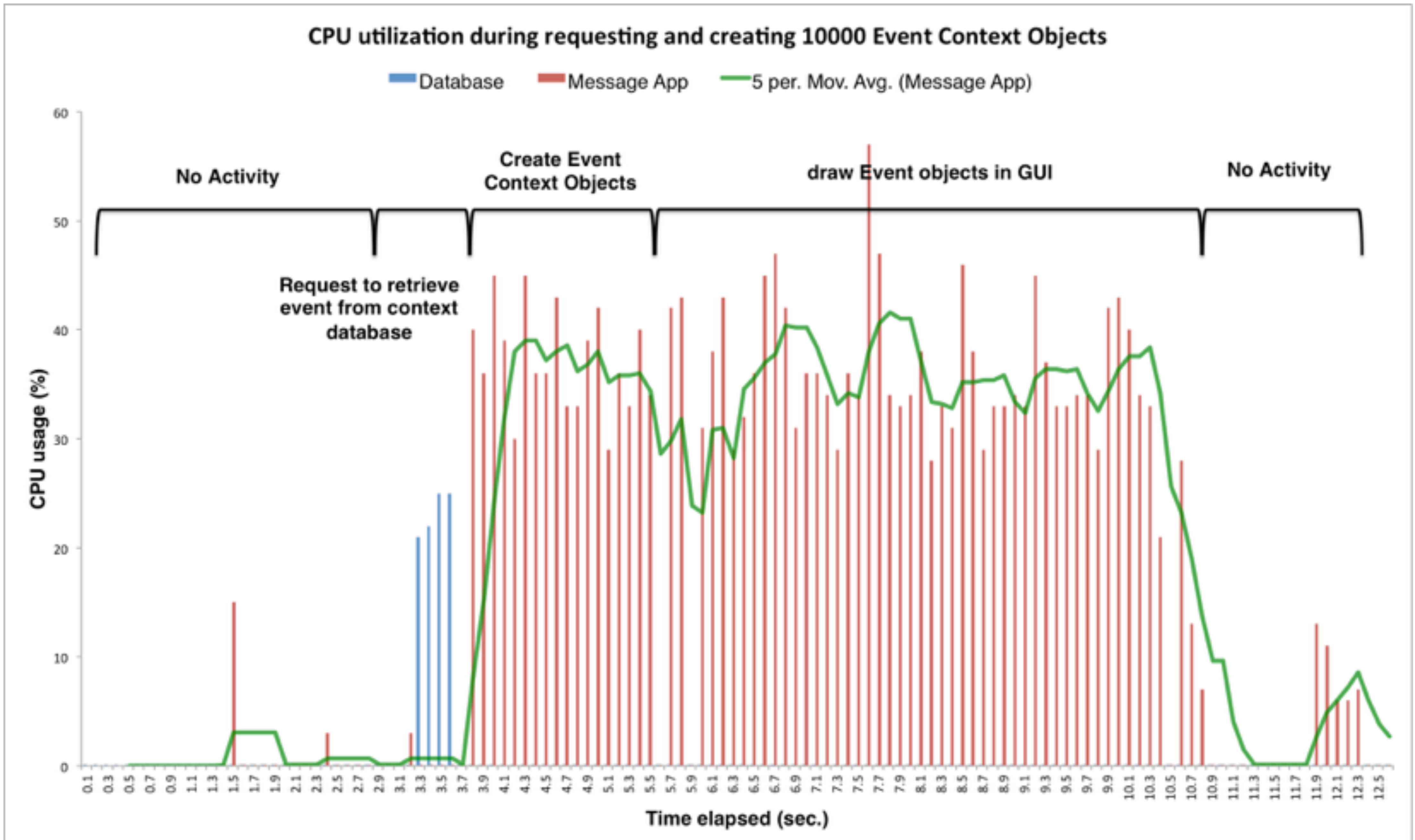
Queries & Size of Database



User perception

- HCI cap for *lag* at 100ms [6]
- Restrict optimum size to keep query operations within 100ms
- Either trim database, or limit results returned via querying

CPU load



CPU utilization during requesting and creating 10000 Event Context Objects
Database
Message App
5 per. Mov. Avg. (Message App)
No Activity
Create Event Context Objects
draw Event objects in GUI
No Activity
Request to retrieve event from context database
CPU usage (%)
Time elapsed (sec.)

Security and Privacy

- Very difficult to recognise app operational intent
- Use existing permissions model to access contexts
- App declare at compile-time what contexts they wish to use / access
- System checks at run-time for operational permissions

Conclusion

- Useful model to offset device limitations, and offer better services to users
- Practically feasible as seen from implementation
- Apps can design new services and features based on availability of contextual information

Future - Ideas

- Extend the model to include cloud storage / models
- Cloud has more processing and storage power, can come up with better relations and use cases
- Device datastore can act as local copy or cache
- Contextual model can be used to develop entirely new services for IoT

“End of presentation”

Points I’m aware of, but not included in the slides due to time constraints

Context Definition

- Use of formal existing schemas to define knowledge facts and queries
- Store relation between contexts instead of embedding them
- Complexity of embedding/extending contexts as opposed to having schema less data fields

Points I’m aware of, but not included in the slides due to time constraints

Context Datastore

- Store data in the cloud, do the processing there, return results. REST API or similar.
- Whether apps own the data, can they freely write or change data records.
- Contextual clashes - when two apps try to change the same data record with different contexts

Points I’m aware of, but not included in the slides due to time constraints

Implementation

- Other databases - NoSQL (document, graph)
- iOS implementation or its challenges and limitations
- Deletion policy via paging algorithms - FIFO, LIFO, etc.

Points I’m aware of, but not included in the slides due to time constraints

Usability

- User Testing
- Perceptions of usefulness
- Stress testing of implementation

Points I’m aware of, but not included in the slides due to time constraints

Adoption

- Ease of adoption for existing apps
- Ease of adoption for existing platforms (Android/ iOS)
- Extend to other devices - IoT, wearables, etc.

References

1. “Gartner Says Worldwide Traditional PC, Tablet, Ultramobile and Mobile Phone Shipments Are On Pace to Grow 6.9 Percent in 2014.” http://www.gartner.com/ document/2685317, June 2014.

2. S. Perez, “comScore: In U.S. Mobile Market, Samsung, Android Top The Charts; Apps Overtake Web Browsing..” http://techcrunch.com/2012/07/02/ comscore-in-u-s-mobile-market-samsung-android-top-the-charts-apps- overtake-web-browsing/, Sept. 2014.

3. M. B¨ohmer, B. Hecht, J. Sch¨oning, A. Kru¨ger, and G. Bauer, “Falling Asleep with Angry Birds, Facebook and Kindle: A Large Scale Study on Mobile Application Usage,” in Proceedings of the 13th International Conference on Human Computer Interaction with Mobile Devices and Services, MobileHCI ’11, (New York, NY, USA), pp. 47–56, ACM, 2011.

4. M. Elgan, “Smart apps think (so you dont have to).” http://www. computerworld.com/article/2496110/ mobile-apps/smart-apps-think-- so-you-don-t-have-to-.html, Mar. 2013.

5. A. K. Dey, “Understanding and Using Context,” Personal Ubiquitous Comput., vol. 5, pp. 4–7, Jan. 2001.

6. M. Jovic and M. Hauswirth, “Performance testing of gui applications,” in Software Testing, Verification, and Validation Workshops (ICSTW), 2010 Third Interna- tional Conference on, pp. 247–251, April 2010