Designing Content-driven Intelligent Notification Mechanisms for Mobile Applications

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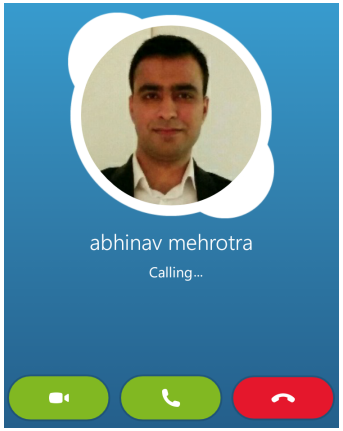
Key Benefits of Mobile Notifications

- For a **recipient**, it provides an effortless way to be aware of newly available information in real-time.

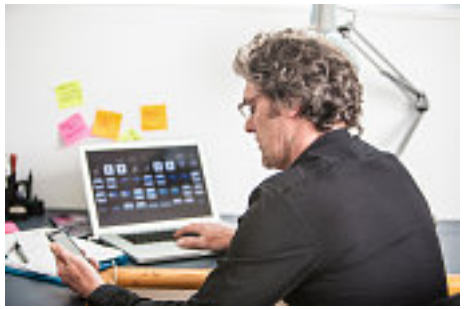
- For a **sender**, it provides a mechanism to initiate a remote communication.



Issues with Mobile Notifications

Notifications cause disruption on arriving at inopportune moments.

Notifications can be ignored if they do not arrive at the right moments.



Interrupt ongoing tasks

Interfere with our lifestyles

Arrive at socially inappropriate moments

Goal: delivering the right information (**notification content**) at the right moment (**context**).

Limitations of Previous Approaches

- Interruptibility is inferred from the sensed context, assuming that a user reaction is the same irrespective of the content and sender.

Missing: Use of notification content and sender information.

- Interruptibility models are trained with experience sampling method (ESM) and artificial notifications sent by the system.

Missing: Models built on real-world notifications received in the wild.

V. Pejovic and M. Musolesi. InterruptMe: Designing Intelligent Prompting Mechanisms for Pervasive Applications. In UbiComp'14, Seattle, WA, USA, September 2014.

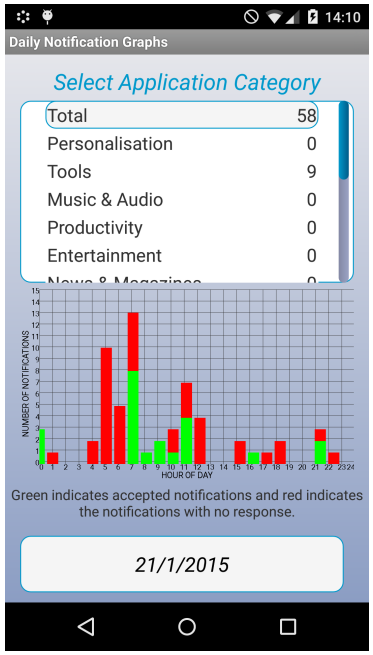
Bridging the Gap

First *in-the-wild* study for predicting interruptibility by using:

- *information type*
- *recipient-sender relationship*
- *context data*

Data Collection

NotifyMe app



1. User's interaction with notifications:
   - **Contextual information.**
   - **Notification data.**

2. User preferences:
   - **Where** would you like to receive notifications with similar content?
   - **When** would you like to receive notifications with similar content?

NotifyMe Dataset

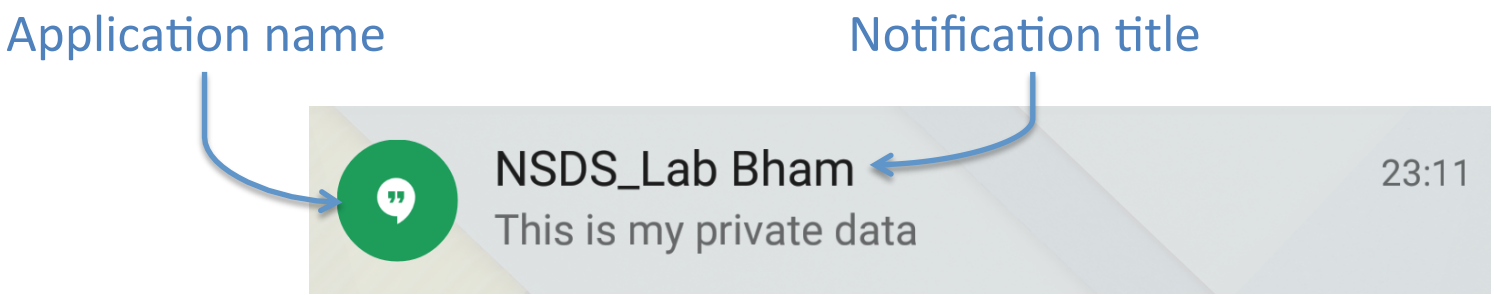
Participants: 35

Study duration: 3 weeks

Notification samples: 70,000 (approx.)

Questionnaire responses: 4,069

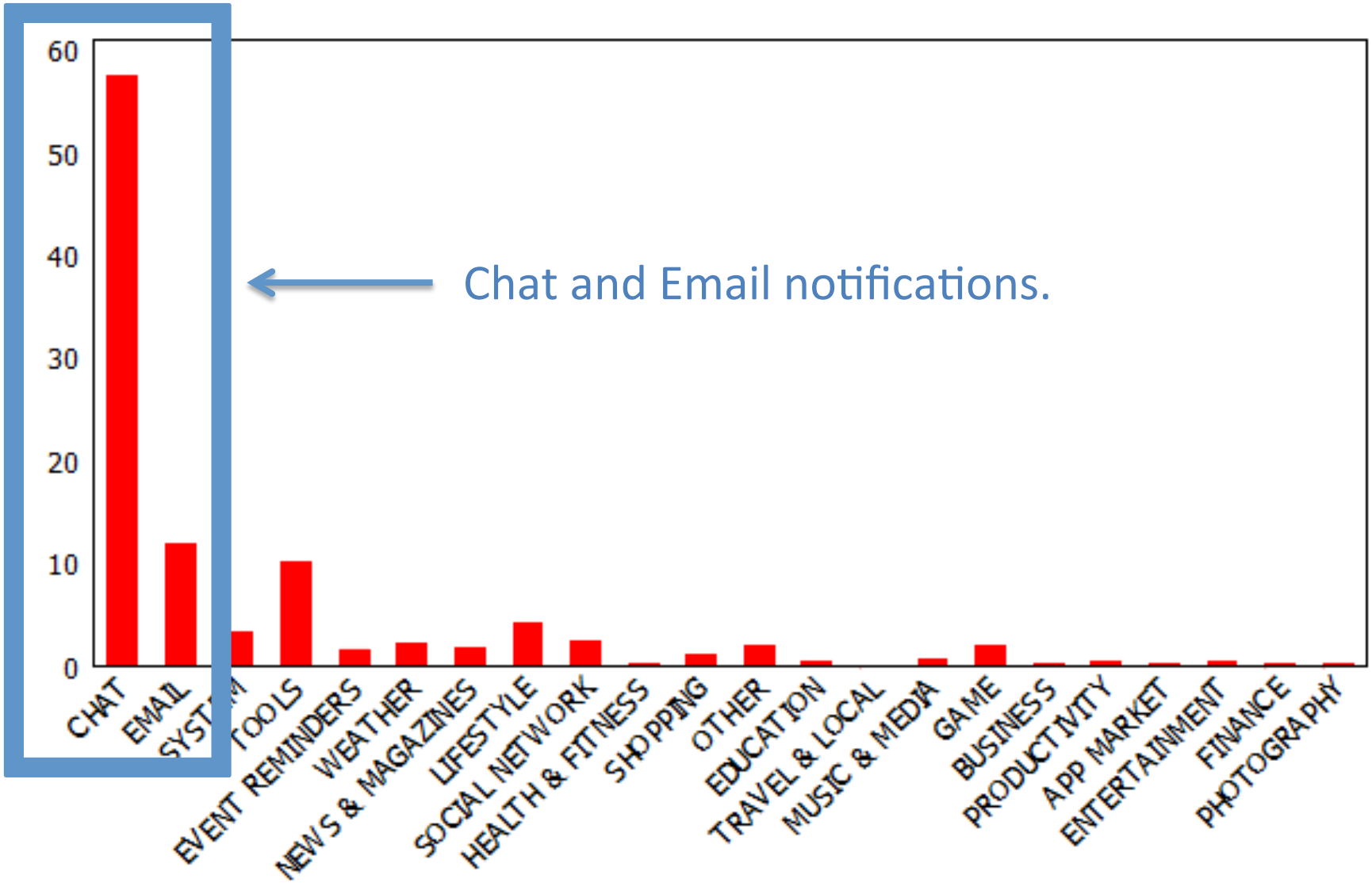
Extracting “Information Type” and “Recipient-Sender Relationship”



Information type: manual classification of application name.

Recipient-sender relationship: users classified their notification titles in 4 categories, namely *Family*, *Friend*, *Work*, *Other*.

Types of Notifications



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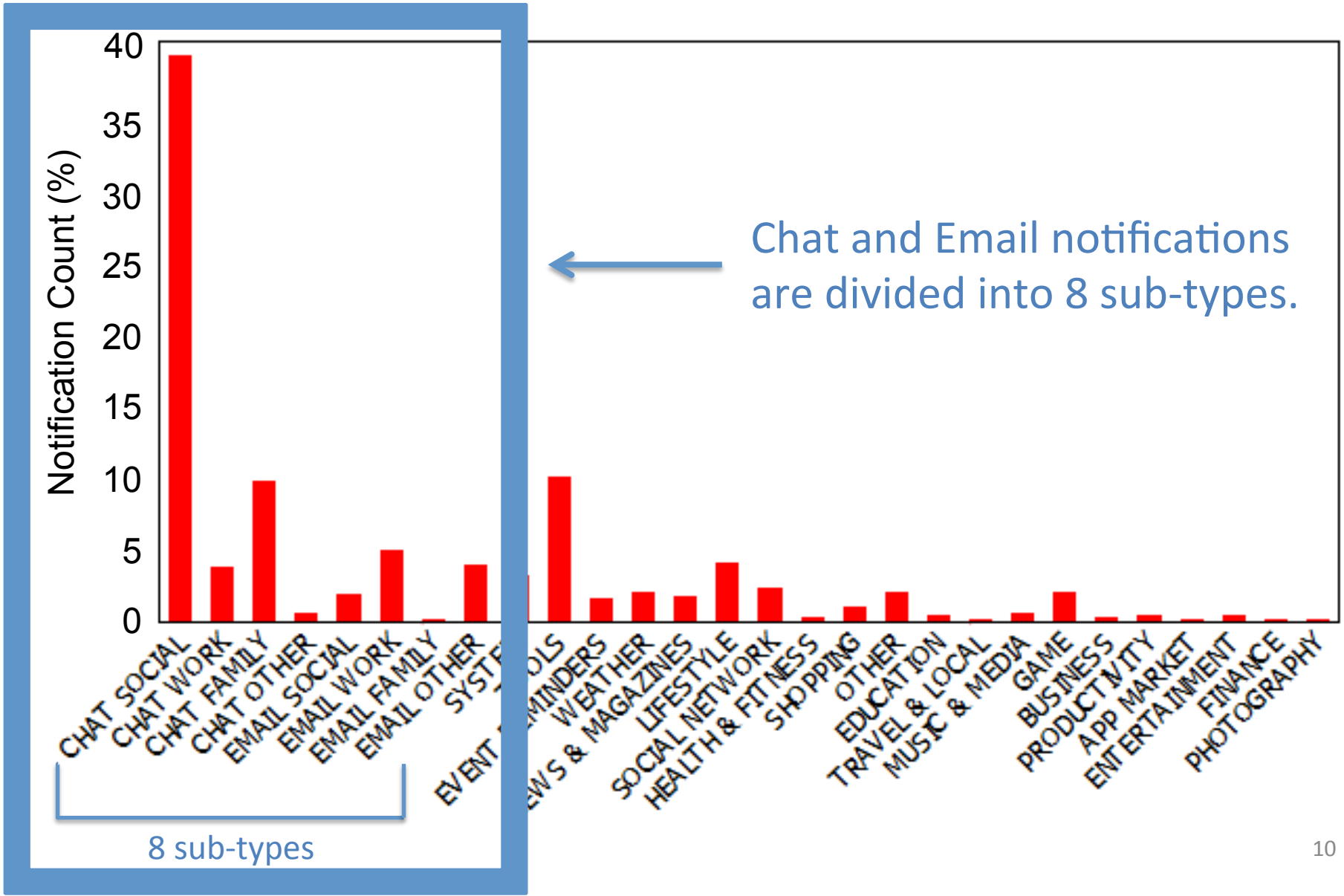
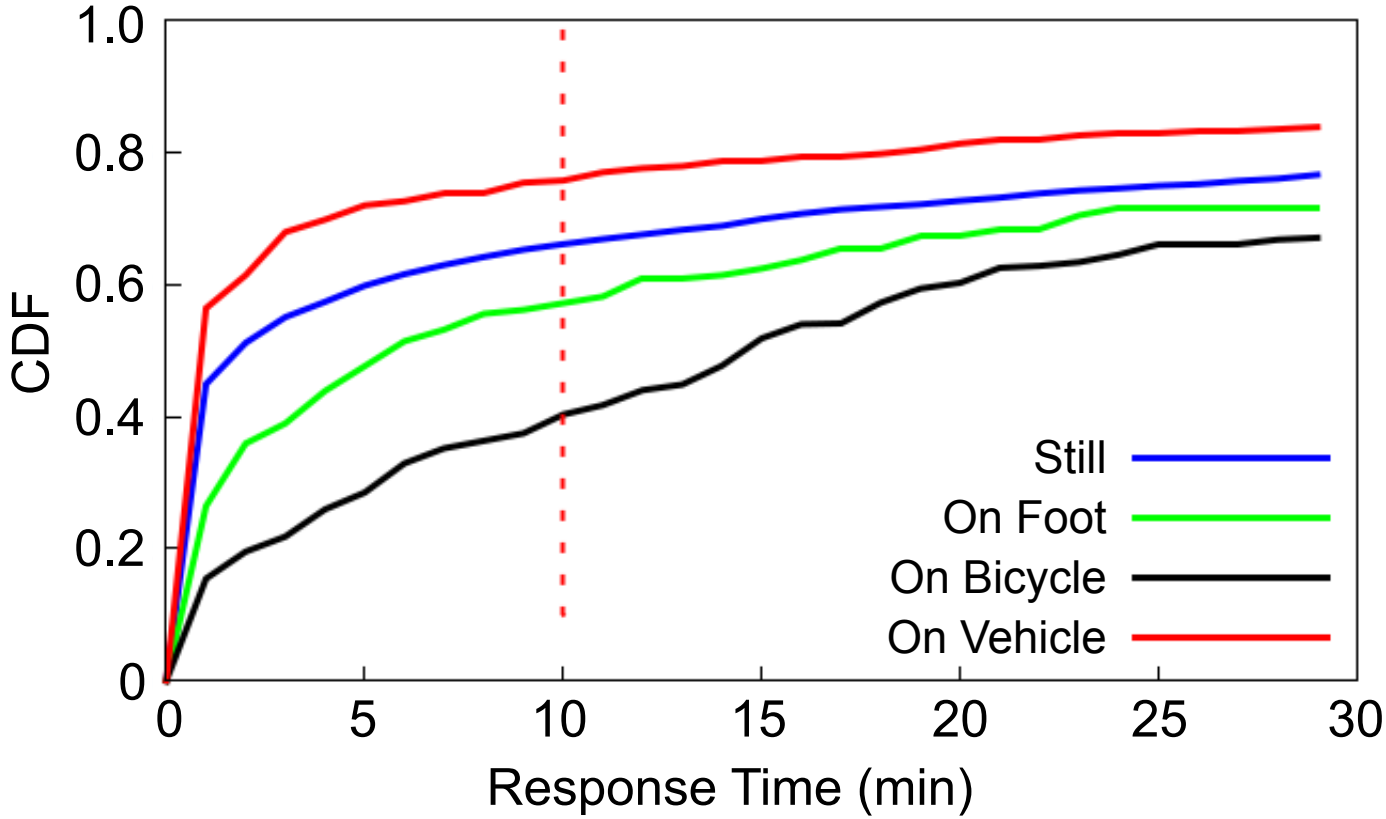


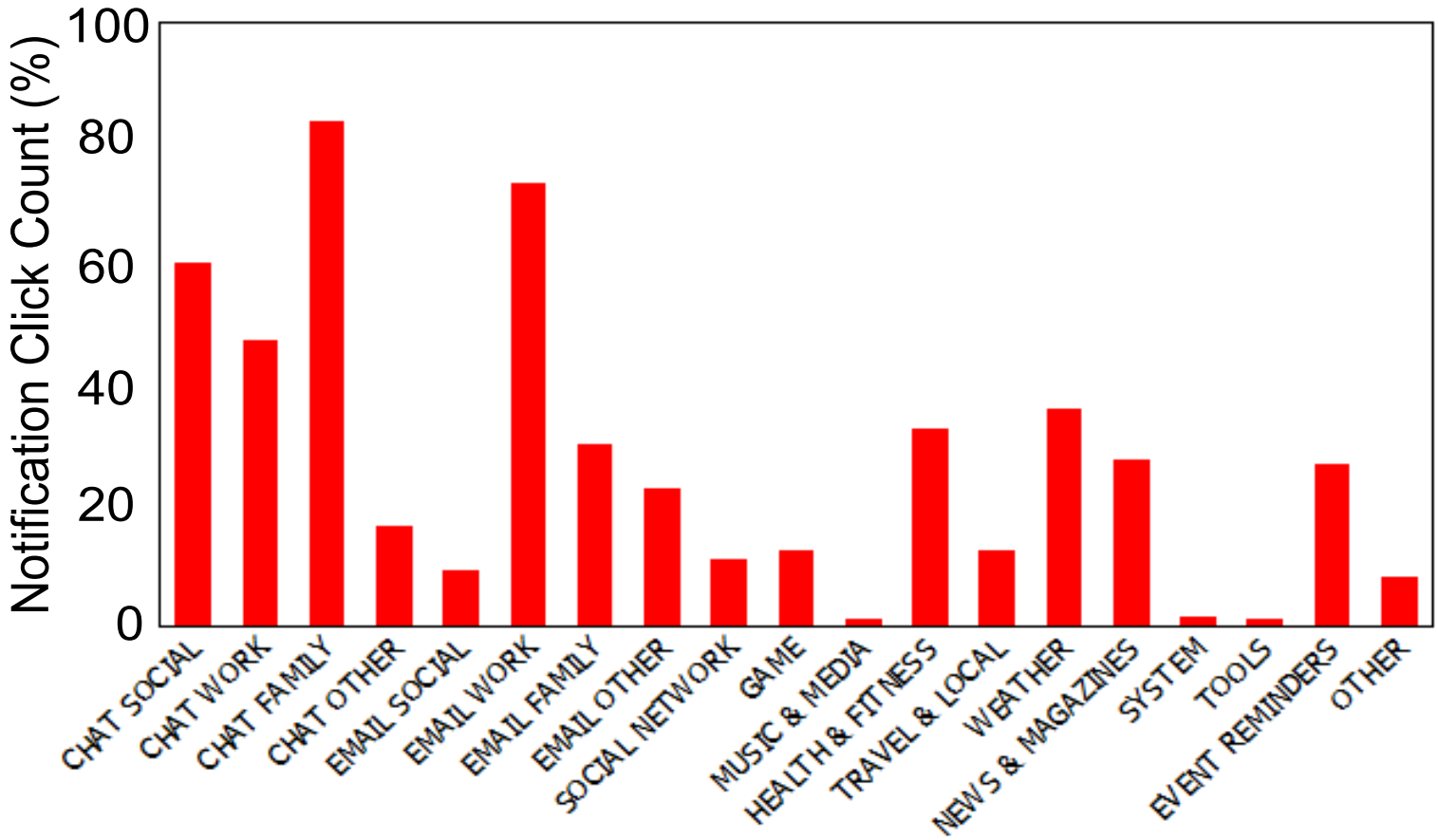
Understanding Interruptibility

Impact of Context on Response Time



Note: the average response time of a notification does not vary with other context modalities including location and presence of the surrounding sound.

Impact of Content on Notification Acceptance: Click Count Percentage



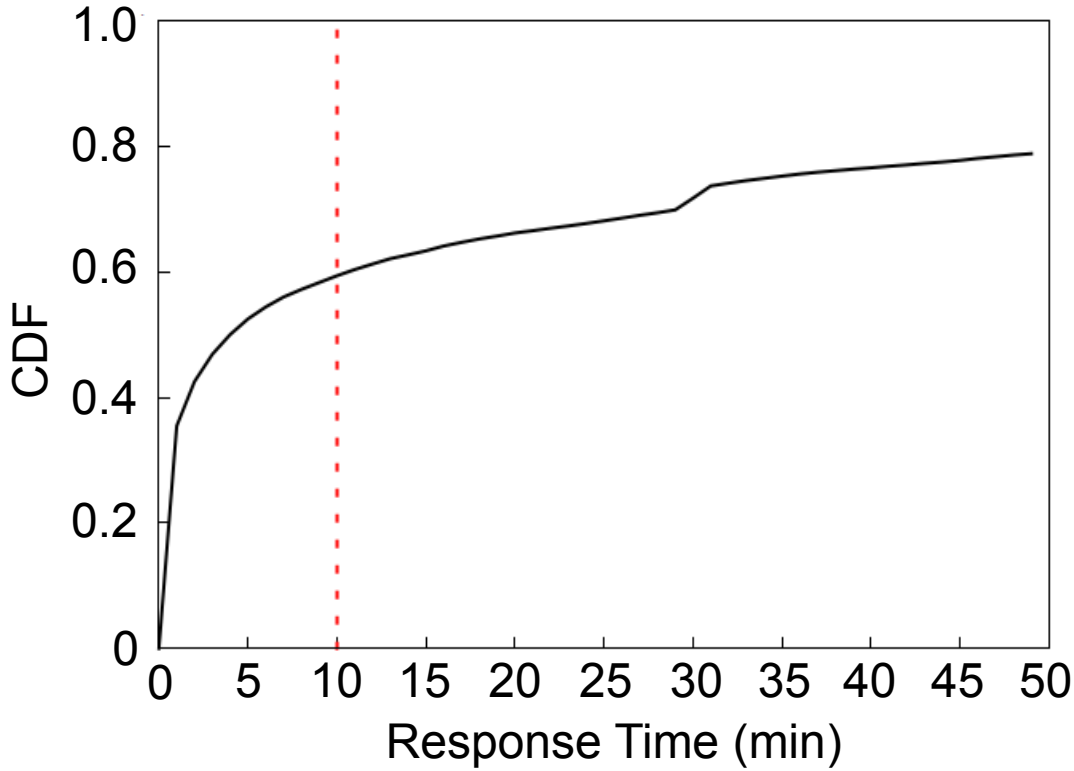
Notification click count refers to the percentage of notifications that are clicked out of total notifications of a specific category.

Predicting an Opportune Moment To Deliver a Notification

What Defines an Opportune Moment?

It is a moment in which a user **quickly** and **favorably** reacts to a notification.

How quick should it be?



Constructing Predictors

Four predictors using different features:

1. User-defined rules and context data.
2. Context data.
3. Information type and context data.
4. Social circle, information type and context data.

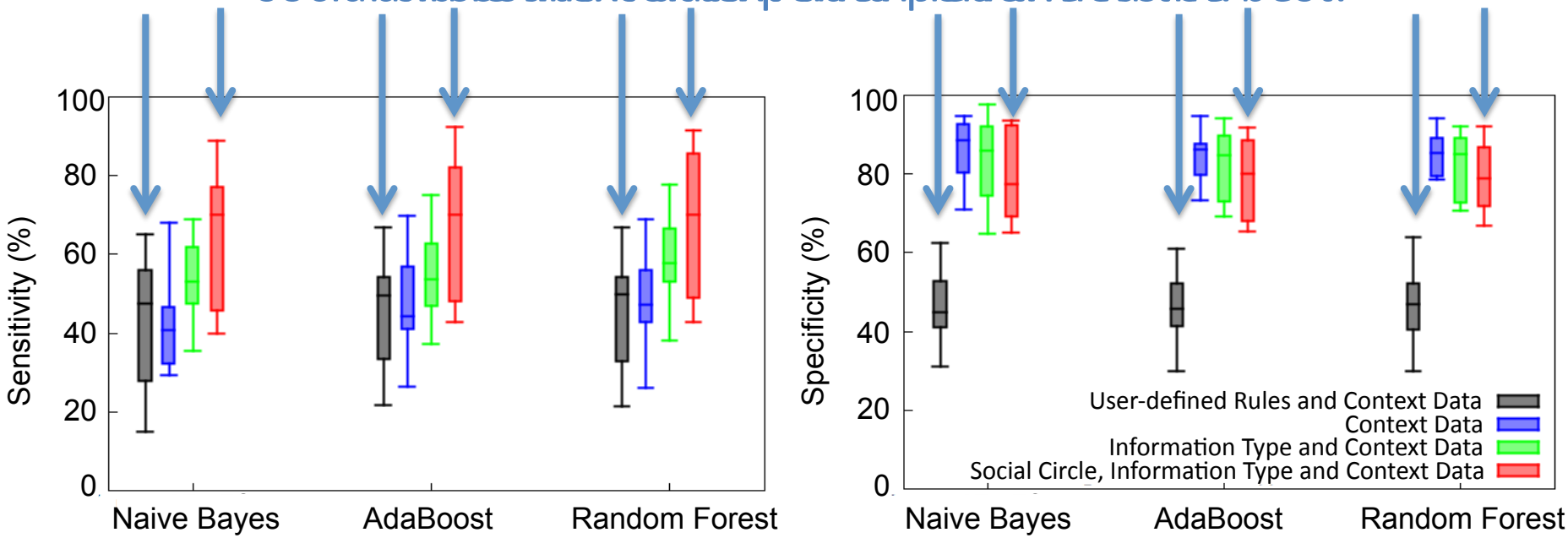
Three ML algorithms:

1. Naïve Bayes
2. AdaBoost
3. Random forest

Prediction Results

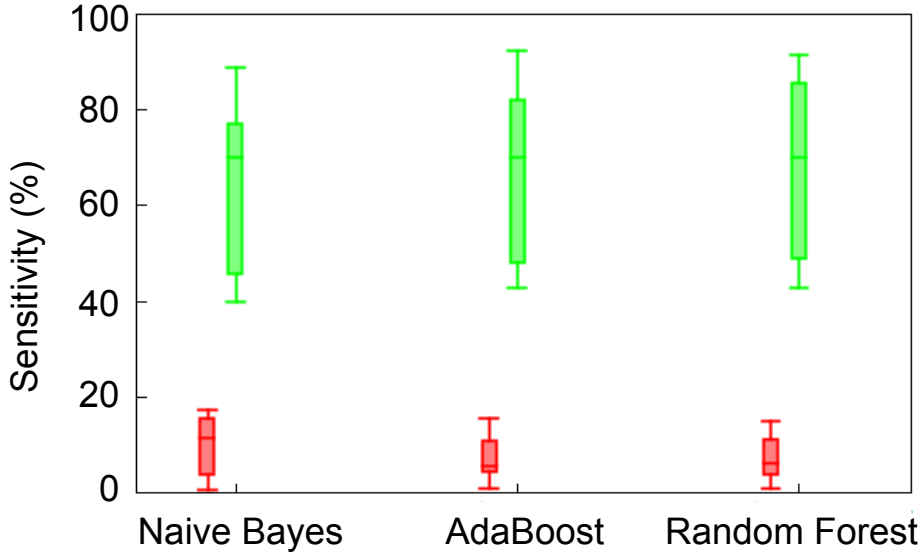
Predictor trained with the user-defined rules, social circle and context data performed the worst.

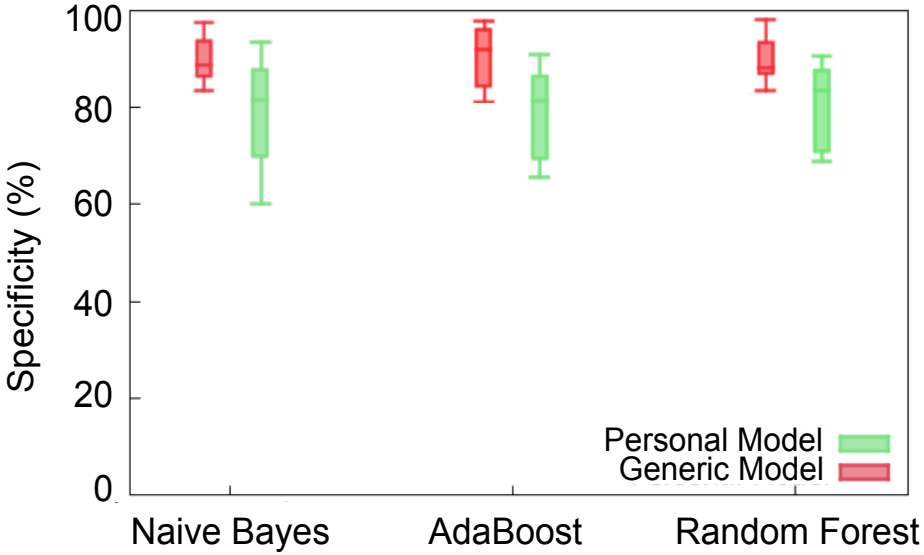
Predictor trained with the information type, social circle and context data performed the best.



By using information type and social circle we were able to predict the acceptance of a notification within 10 minutes from its arrival time with an **average sensitivity of 70% and a specificity of 80%**.

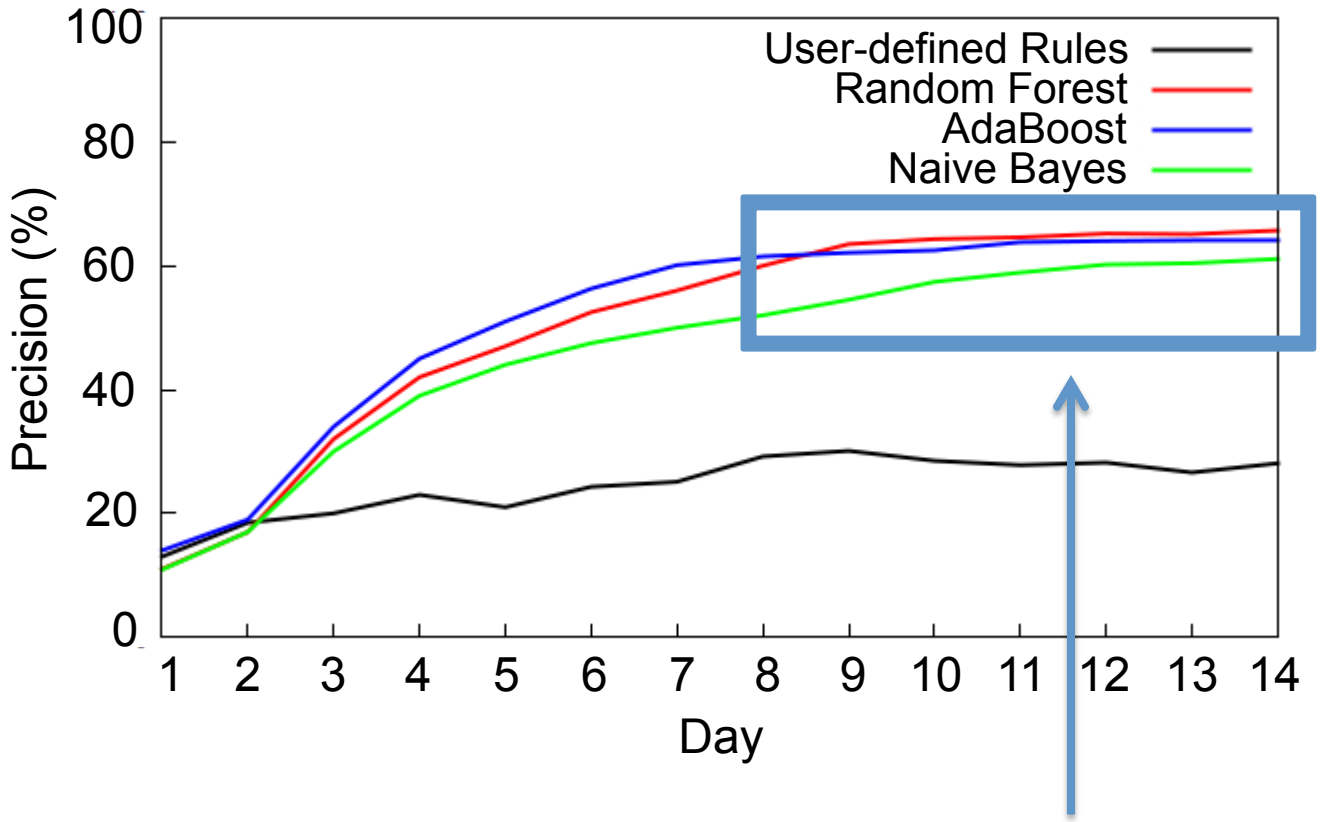
Generic vs Personal Behavioural Model





All predictors are trained with social circle, information type and context data.

Online Learning



The inference of a user's interruptibility can be performed locally in an online fashion, achieving more than **60% precision** after **nine days** of training.

Summary

- First *in-the-wild* study that uses **content** (information type, recipient-sender relationship) and **context** to model interruptibility.

- The acceptance of a notification within 10 minutes from its arrival time can be predicted with an **average sensitivity of 70%** and a **specificity of 80%**.

- An online predictor can start making stable predictions after **nine days** of training.

Open Issues

- How to infer the user's willingness to receive a notification?
- How to capture the level of user's engagement with the current task, difficulty of the interrupting task, and similar factors that might influence interruptibility?
- How does the user reacts when notifications are stacked by applications?

Thank You!

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