Human-Centric Access Control

INFR11158/11230 Usable Security and Privacy

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Overview

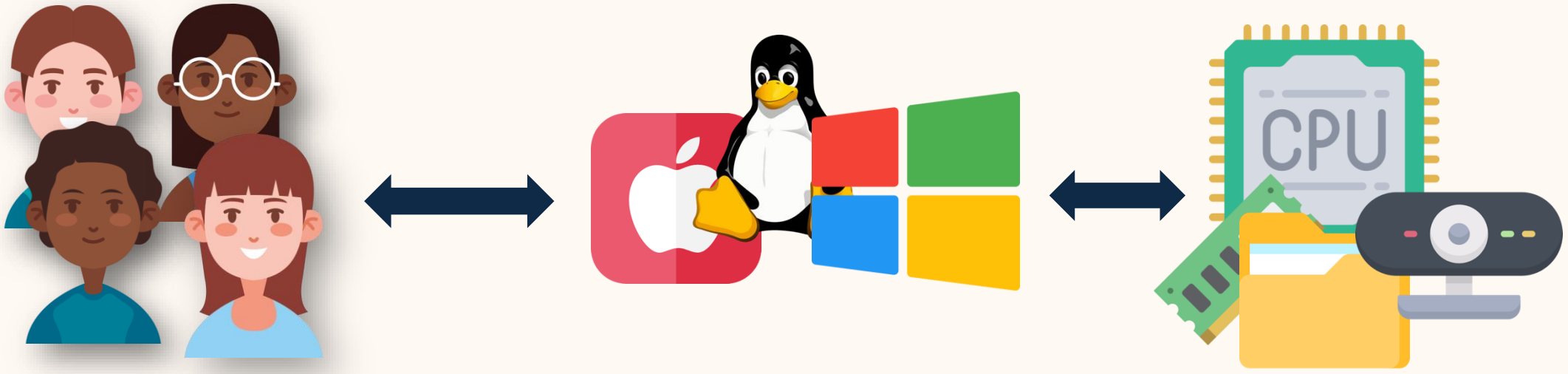
- Warm-up
- Access control basics
- Framework & advice
- Take-home

https://www.youtube.com/watch?v=SdPvatF5UpA

What is Access Control?

Can I walk into all these labs?

What is Access Control?



OS manages many different resources (memory, storage, CPU, network, other sensors, etc.)

Control who is permitted to access and what they can do with the resources

Modeling access control and protection

Subjects and Objects

Subjects/users

/home/jingjie

./research

./teaching

./taxfile

/home/bob

./lectures

./projects

./gitbucket

/home/alice

./Projects

./homework

./Courses

Objects

/etc/init.d

./sshd

./xrdp ....

Access Control Matrix

Objects (files)

Subjects (users)

	a	b	c	d	e
jingjie	r,w	-	r,w, own	-	r
bob	-	-	r	r	r,w
alice	w, own	r	r	-	-
eve	r	r,w	r,w	-	r

Permitted operations

[Lampson, Graham, Denning; 1971]

Could be a very huge table to store and access!

Access Control Matrix: Access Control List

Objects (files)

Subjects (users)

	a	b	c	d	e
jingjie	r,w	-	r,w, own	-	r
bob	-	-	r	r	r,w
alice	w, own	r	r	-	-
eve	r	r,w	r,w	-	r

Permitted operations

Access control list for File a

[Lampson, Graham, Denning; 1971]

Access Control List (ACL)

Column-wise split of access control matrix

Access Control Matrix: Capabilities

Objects (files)

Subjects (users)

	a	b	c	d	e
jingjie	r,w	-	r,w, own	-	r
bob	-	-	r	r	r,w
alice	w, own	r	r	-	-
eve	r	r,w	r,w	-	r

Permitted operations

Capability list for alice

[Lampson, Graham, Denning; 1971]

ACL vs. Capabilities

ACL

Capabilities

ACL vs. Capabilities

ACL

- Each file contains lists of user ids with their permissions (column in AC matrix)
- Check user/group against ACL
- Relies on authentication
- Inefficient run-time security checking

Capabilities

- Stores each user's capabilities (row in AC matrix)
- Check validity of capability
- Can be easily passed to other subjects (delegation)
- Hard to change a file's status globally, e.g., revocation

Overview

- Modelling access control protection
- **Access control mechanisms and policies**
- UNIX access control
- Extended reading: smart home access control policies

Access Control Mechanisms and Policies

Discretionary Access Control (DAC)

- Access granted based on **identity alone** (no respect to the sensitivity of objects).
  - Any propagation of information is allowed. (Access => Sharing)
  - Windows 98

Mandatory Access Control (MAC)

- Access granted based on **identity and the sensitivity** of the object.
  - Sharing or any operation on the resource is restricted by security policies
  - Android (somewhat)

Role-based Access Control (RBAC)

- Mix of DAC and MAC. Users are assigned to **groups (roles)**, and objects have labels specifying which group can do what to an object.
  - Linux

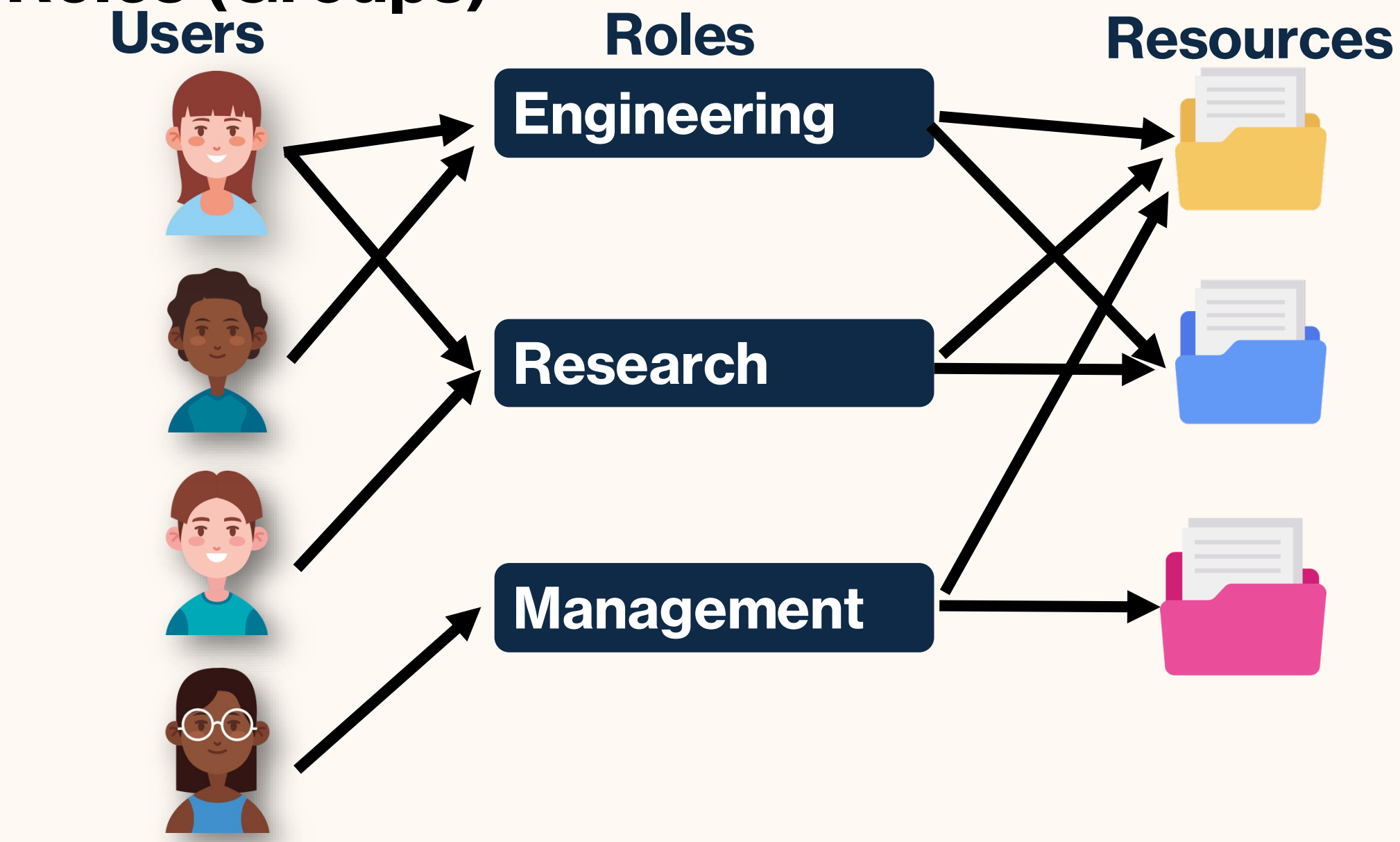
Mandatory Access Control

- The security policy has the ultimate control. Users cannot override the policy.

Bell-LaPadula

- Multi-level security
- Designed for **confidentiality**

Roles (Groups)



Overview

- Modelling access control protection
- Access control mechanisms and policies
- **UNIX access control**
- Extended reading: smart home access control policies

UNIX Access Control

- Unix uses **role-based access control**
  - Role => group
  - Individual (or process) => user id (uid)

- Special user ID: uid 0
  - root user
  - **permitted to do anything**
  - for any file: can read, write, change permissions, change owners

- Each file has
  - Owner
    - User
    - Group
  - ACL
    - Owner's access
    - Group's access
    - World's access

UNIX Access Control

View file permissions

```
jingjieli@jingjiedeMacBook-Pro CCS2019 % ls -l
total 15536
drwxr-xr-x@ 10 jingjieli  staff      320 Mar  8 16:55 CCS_Reimbursement
drwxr-xr-x@  9 jingjieli  staff      288 Mar  8 16:55 DEMO
drwxr-xr-x@ 15 jingjieli  staff      480 Mar  8 16:55 TRAVELGRANT
-rw-r--r--@  1 jingjieli  staff  7951483 Feb  4  2020 VELODY.gif
```

Access control list

Owner

Group

```
jingjieli@jingjiedeMacBook-Pro CCS2019 % groups jingjieli
staff everyone localaccounts _appserverusr admin _appserveradm _lpadmin com.apple.sharepoint.group.1 _appstore
ticsusers com.apple.access_ftp com.apple.access_screensharing com.apple.access_ssh com.apple.access_remote_ae
```

UNIX Access Control

```
jingjieli@jingjiedeMacBook-Pro CCS2019 % ls -l
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-rw-r--r--@  1 jingjieli  staff  7951483 Feb  4  2020 VELODY.gif
```
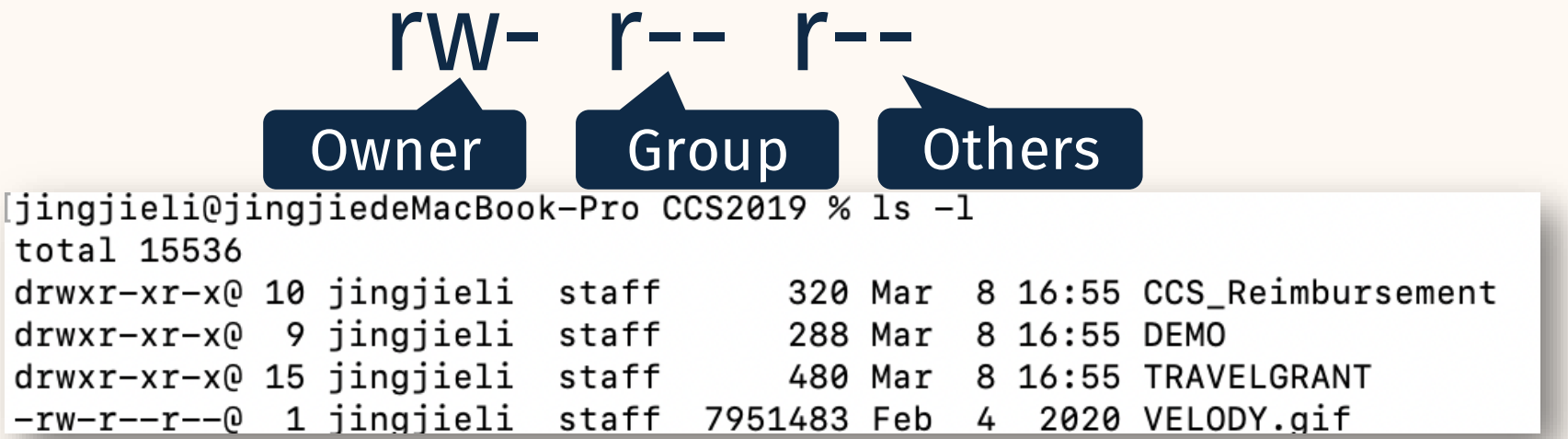

Owner

Group

- Basic operations
  - **R**ead
  - **W**rite
  - E**x**ecute

UNIX Access Control



- Permissions set by owner (or root)
- Determining if an action is permitted:
  - if **uid == 0 (root):** allow anything
  - else if **uid == owner:** use owner permissions
  - else if **uid in group:** use group permissions
  - else: use other permissions
- Only owner, root can change permissions
  - This privilege cannot be delegated or shared

Exercise

```
-rw-r--r--  1 ace  staff  1087 Aug 10 15:20 LICENSE.txt
-rw-r--r--  1 ace  staff    19 Aug 10 15:57 MANIFEST.in
-r---w-r--  1 ace  dev    1106 Aug 14 13:55 README.md
drwxr-xr-x  3 ace  staff   102 Aug 13 07:27 dist
drwxr-xr-x  8 ace  staff   272 Aug 13 10:47 safeid
drwxrwxr-x  9 ace  staff   306 Aug 13 07:26 safeid.egg
-r--------  1 ace  web      40 Aug 10 15:56 setup.cfg
-rw--w-r-x  1 ace  dev    1550 Aug 13 07:26 deploy.log
```

1. Can sscott read the file README.md?
2. Can ace write to setup.cfg?
3. Who can append to deploy.log?

staff:*:29:ace,sscott,kpat,rist
web:*:31:ace,kpat,rist
dev:*:32:ace,sscott,pbriggs

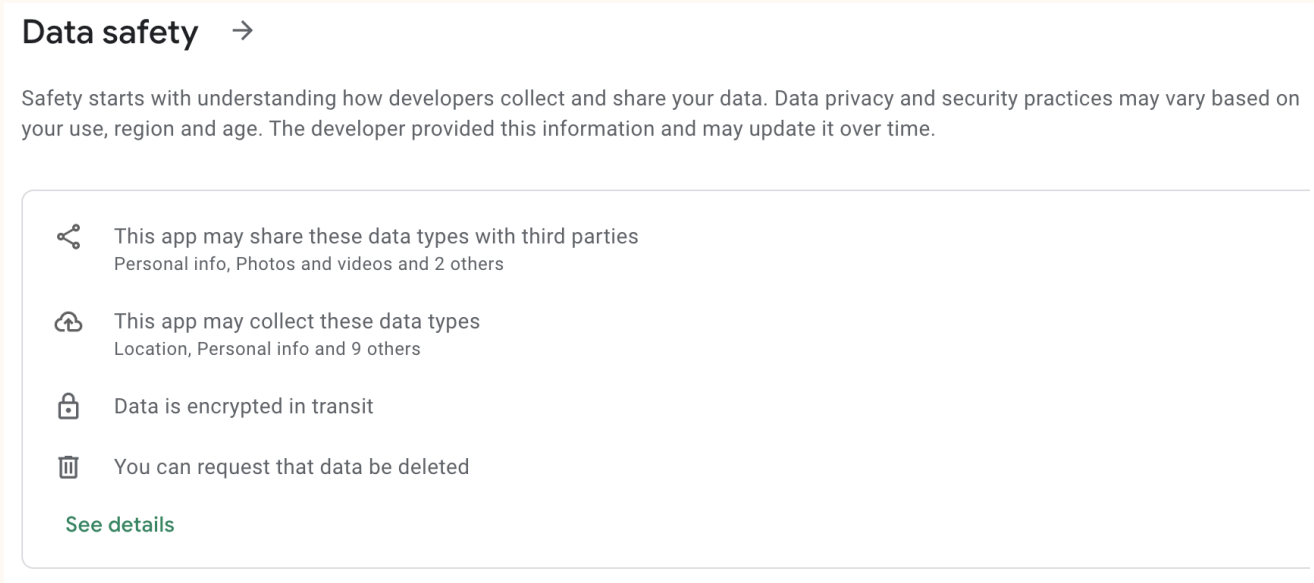
Permission model

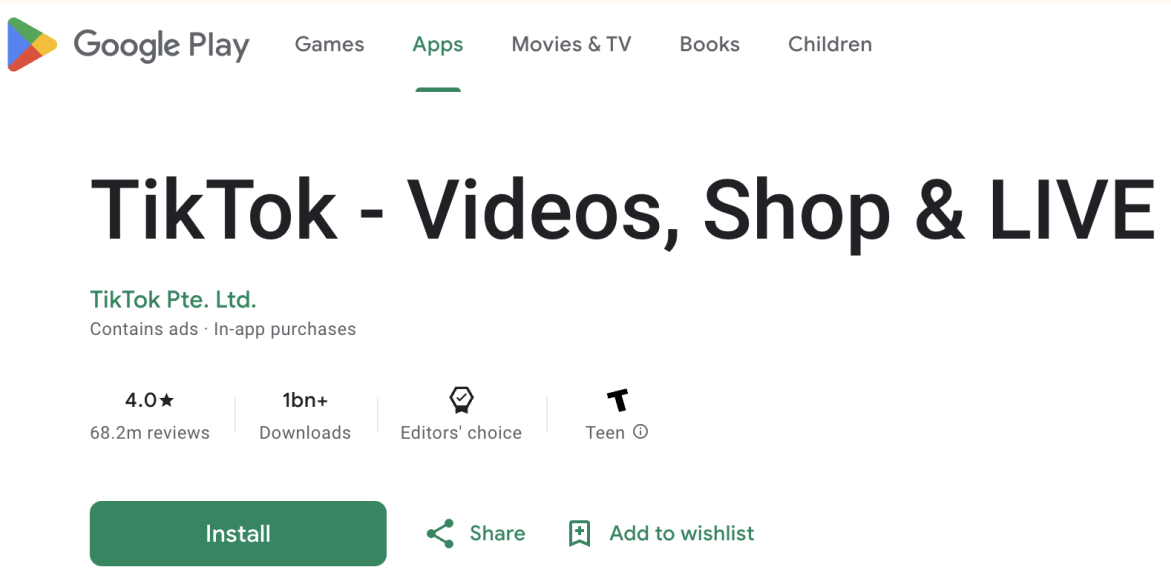
User-centric access control

- People want to be in control when setting up the policy
- People like to be asked permission
- People want to know who is accessing the assets
- People want to review and review policy

Mazurek, M.L., Klemperer, P.F., Shay, R., Takabi, H., Bauer, L. and Cranor, L.F., 2011, May. Exploring reactive access control. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 2085-2094).

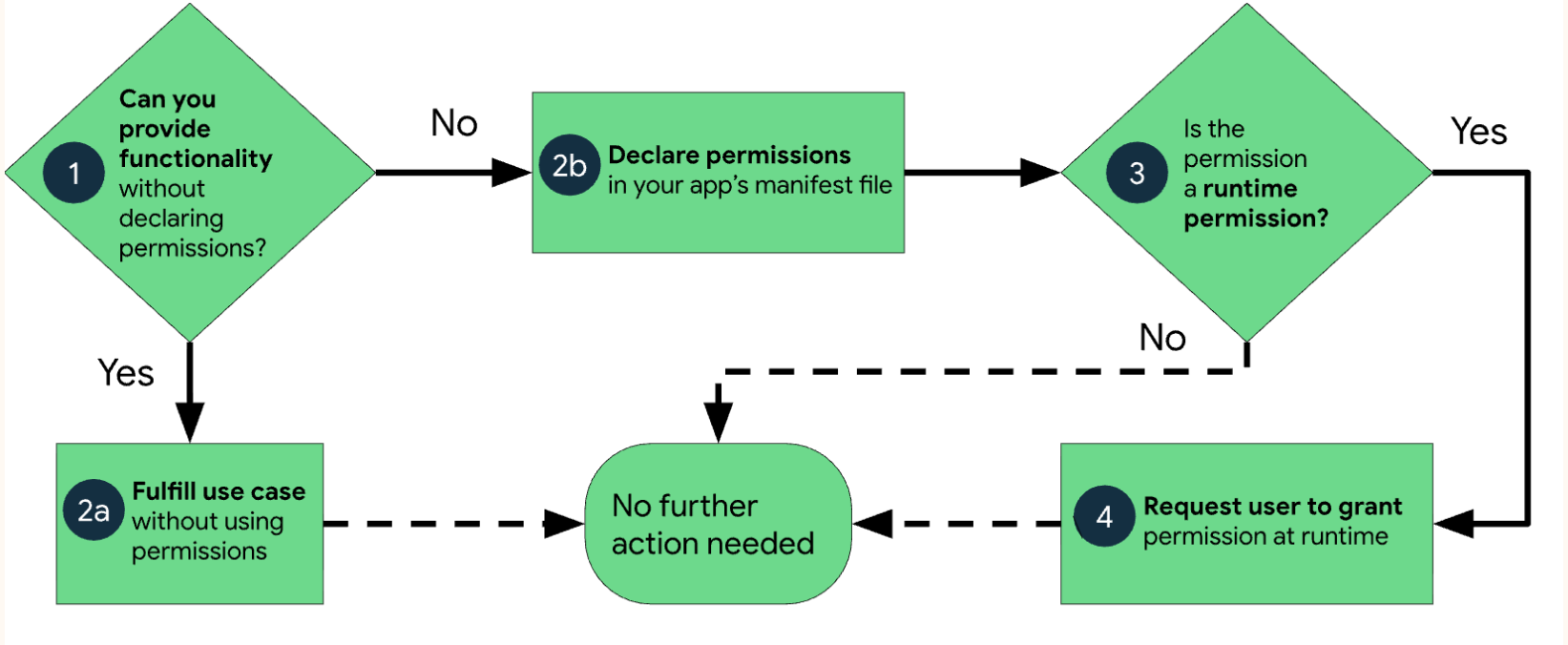
Permission model: making access controls operational for end users





How can developers make permission management easier for the user?

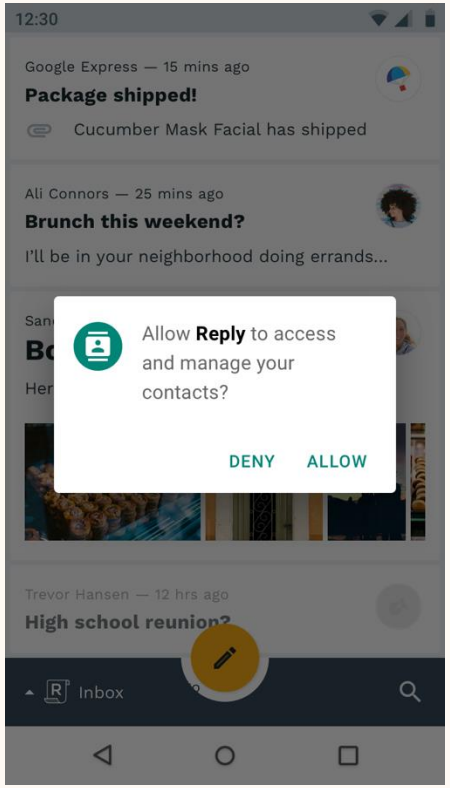
Permission

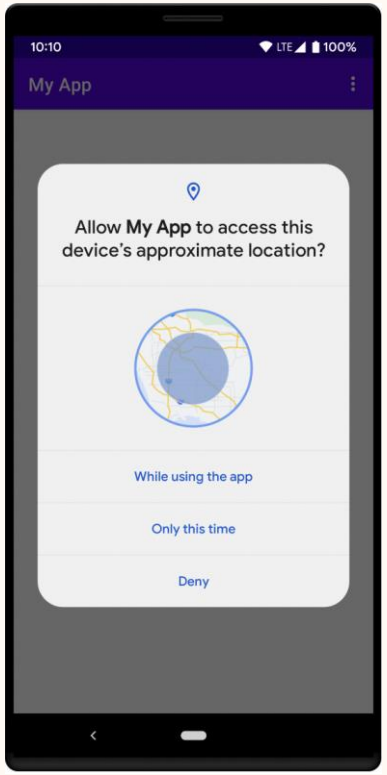


https://developer.android.com/guide/topics/permissions/overview?hl=zh-cn

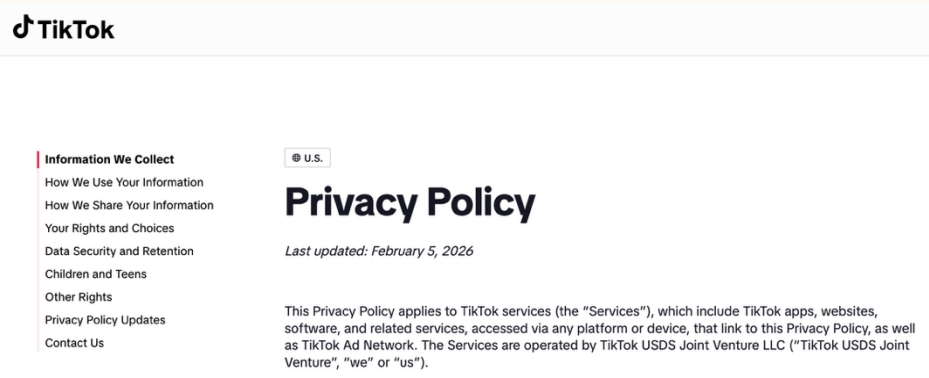
Least privilege principle

- A system should only have the minimal privileges (i.e., resource access) needed for its intended purposes
  - Benefits:
    - Minimizing attack surfaces
    - Reducing human errors
  - Challenges:
    - Requiring compliance
    - Requiring understanding
    - Requiring proper enforcement

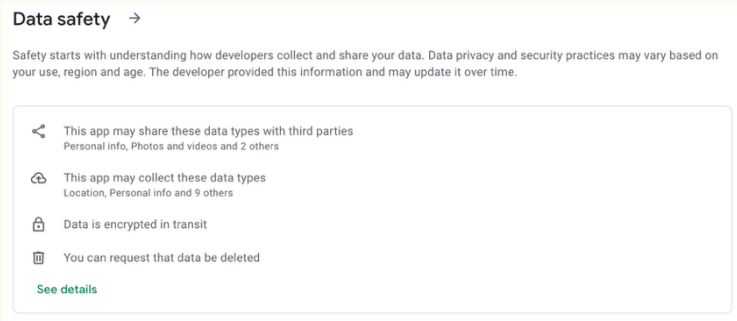




Consistency issues of access control and permission management

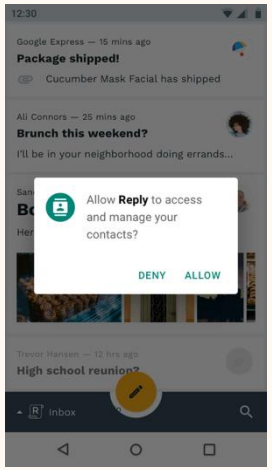


Privacy policy (high level compliance document)

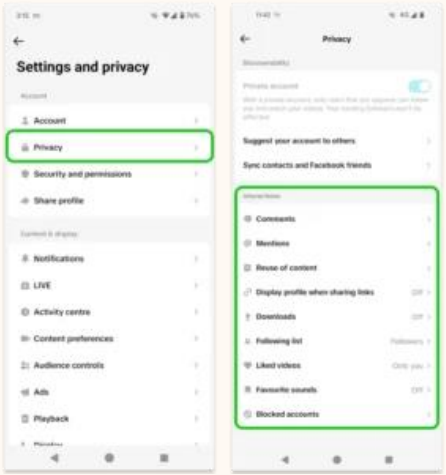


Data safety label (reported by developers)

Permission used by app software



Permission notices



App UI control

User understanding and intention

Think: how could may an AI assistant help manage your permission?

How to make access control and permission management personal?

Rethinking Access Control and Authentication for the Home Internet of Things (IoT)

Weijia He, *University of Chicago;* Maximilian Golla, *Ruhr-University Bochum;* Roshni Padhi and Jordan Ofek, *University of Chicago;* Markus Dürmuth, *Ruhr-University Bochum;* Earlence Fernandes, *University of Washington;* Blase Ur, *University of Chicago*

https://www.usenix.org/conference/usenixsecurity18/presentation/he

This paper is included in the Proceedings of the 27th USENIX Security Symposium.

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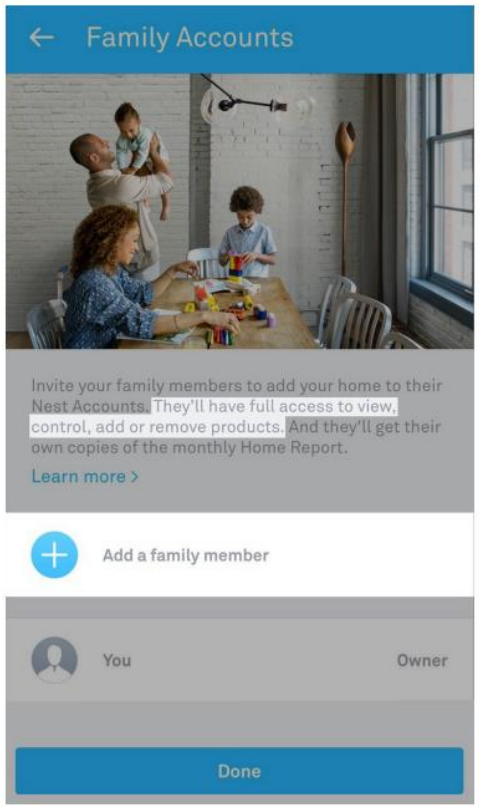
ISBN 978-1-939133-04-5

Motivation

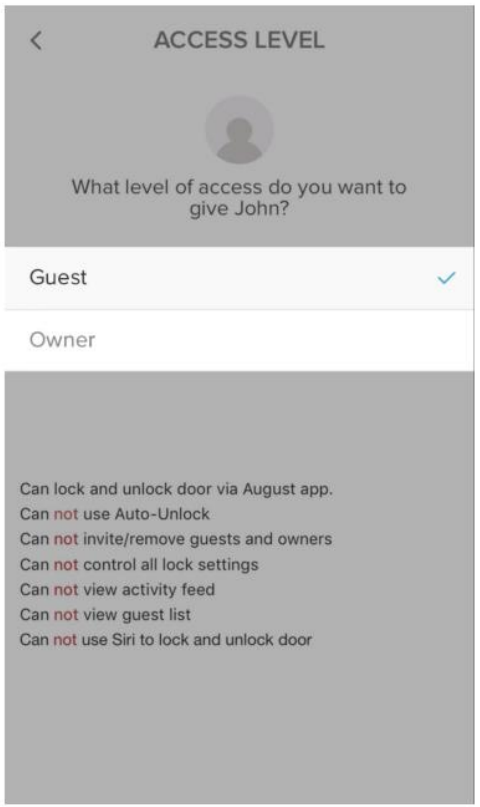
- Smart home devices, e.g., smart door lock, camera, etc., interact with our digital/physical world
- Smart home's security and privacy issues may lead to physical, financial, and mental harms
- Multiple users, who have different security and privacy considerations, reside in one smart home

Research question

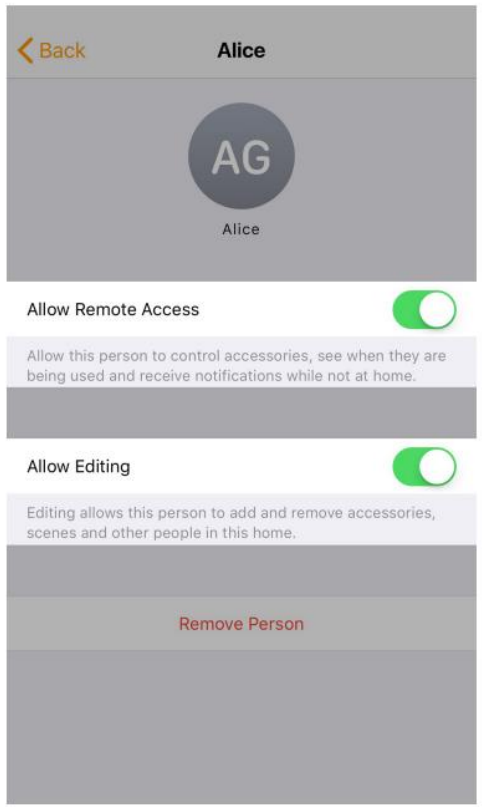
- Do desired access-control policies **differ among capabilities** of single home IoT devices?
- For which pairs of **relationships (e. g., child) and capabilities (e. g., turn on lights)** are desired access-control policies consistent across participants?
- On what **contextual factors** (e. g., location) do access-control policies depend?
- What types of authentication methods balance **convenience and security**, holding the potential to successfully balance the consequences of falsely allowing and denying access?



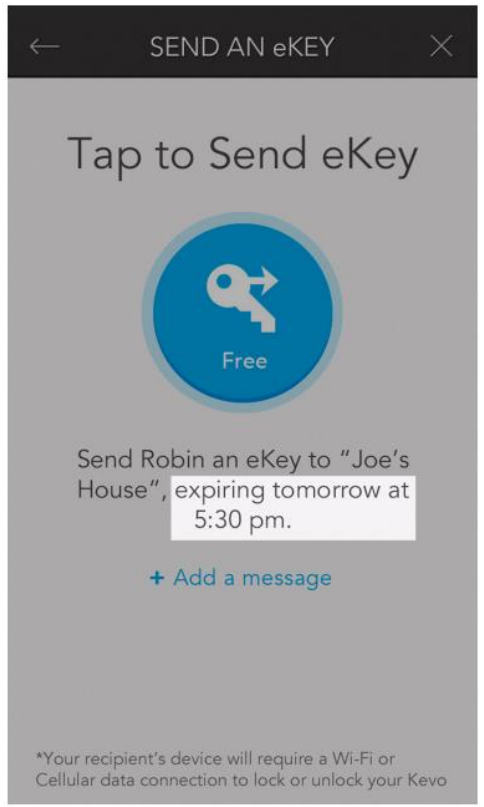
(a) Nest Learning Thermostat



(b) August Smart Lock



(c) Apple HomeKit

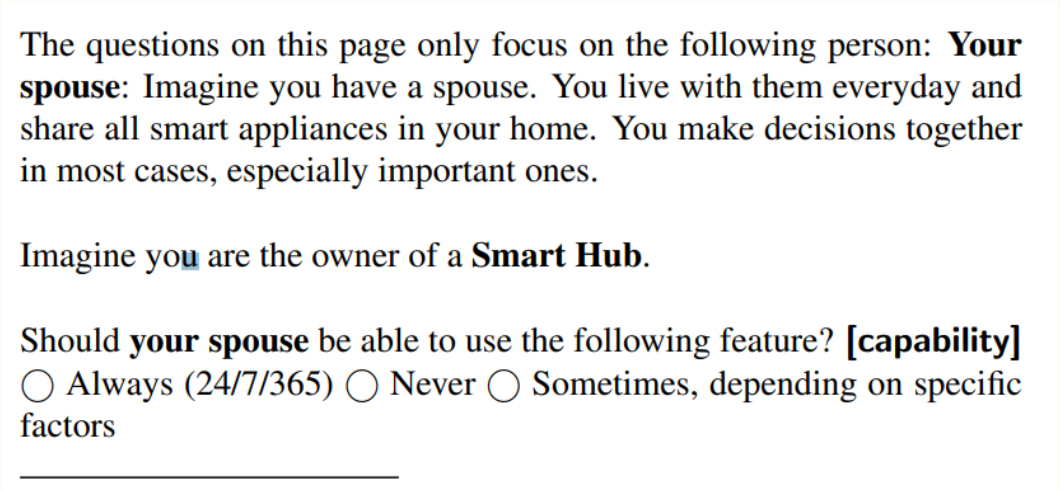


(d) Kwikset Kevo Smart Lock

Figure 1: Current access-control-specification interfaces: The Nest Thermostat (a) only allows "all-or-nothing" specification, while the August Smart Lock (b) only offers coarse-grained access control via predefined Guest and Owner groups. In contrast, Apple's HomeKit (c) differentiates between view and edit access level, as well as local and remote access. The Kwikset Kevo Smart Lock (d) provides time-based access control, but not other factors.

Method

- Pre-study:
  - Find out the categories/capabilities of smart home devices, relationships between family members... for setting up the main study
  - Surveyed 31 participants via Amazon MTurk
- Main study:
  - Quantify people's preferences at scale
  - Surveyed 425 people via MTurk



The questions on this page only focus on the following person: **Your spouse**: Imagine you have a spouse. You live with them everyday and share all smart appliances in your home. You make decisions together in most cases, especially important ones.

Imagine you are the owner of a **Smart Hub**.

Should **your spouse** be able to use the following feature? **[capability]**
◯ Always (24/7/365) ◯ Never ◯ Sometimes, depending on specific factors

Findings

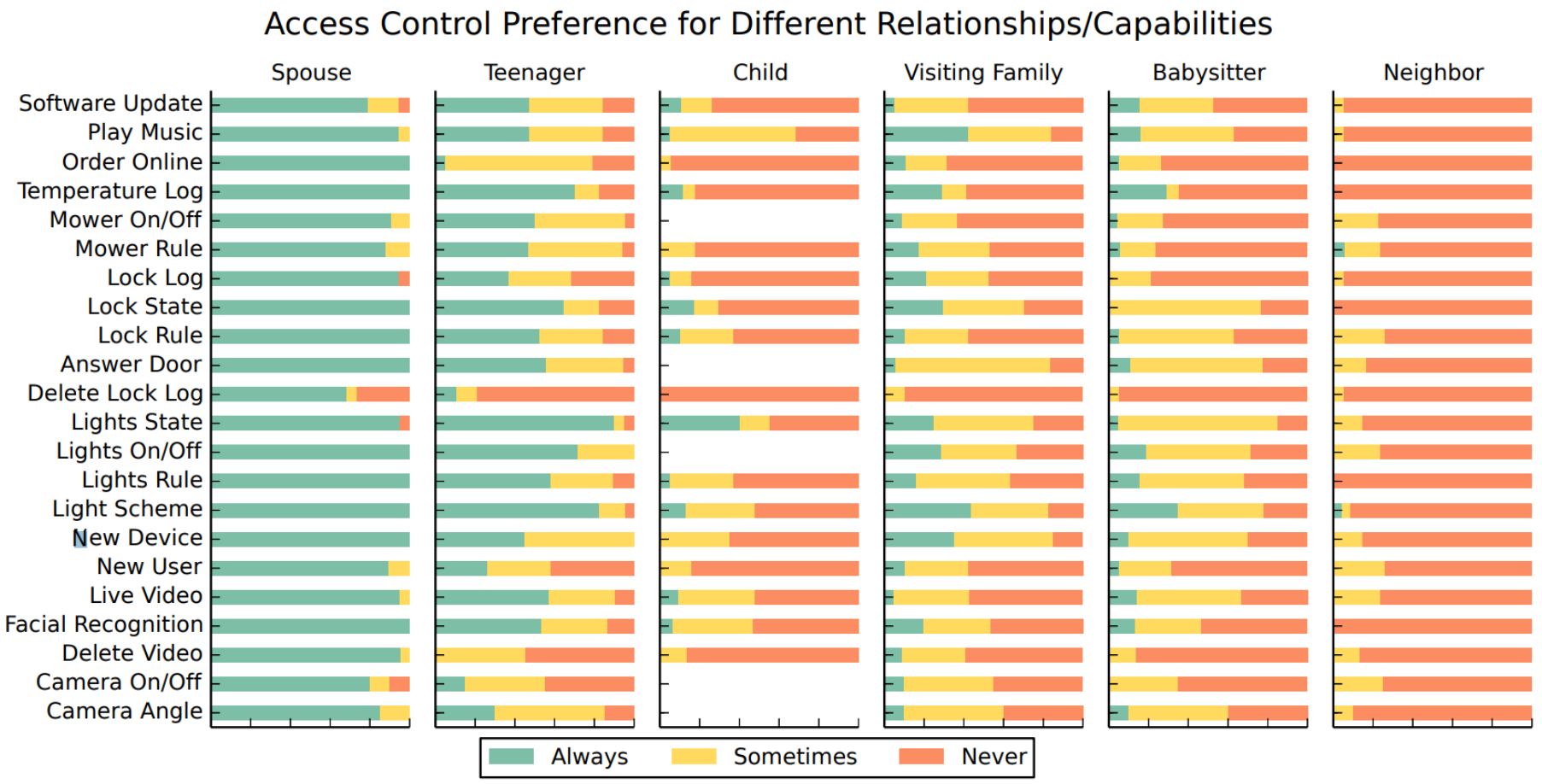


Figure 2: Participants' desired access-control policies. We introduced participants to a list of relationships (e.g., *neighbor*) and asked them to choose whether someone of that relationship should be permitted to "always," "sometimes," or "never" control a capability (e.g., adjust the *camera angle*) in their smart home.

Think: find anything interesting?

Findings

- Access control preferences for different capabilities differ within a single device
- Some control are more context-dependent, e.g., “answering the doorbell” with/without “homeowner” present
- People’s relationships are crucial, while nuances exist, e.g., giving more permissions to babysitters than home visitors particularly for live video rather than other capabilities
- Overall preferences for restrictive policies

Findings

Table 1: Potential default access-control policies that reflected the vast majority of participants' preferences.

All

- *Anyone* who is *currently at home* should always be *allowed* to adjust *lighting*
- *No one* should be *allowed* to *delete log files*

Spouse

- *Spouses* should *always* have access to *all capabilities*, except for deleting log files
- *No one except a spouse* should unconditionally be allowed to access administrative features
- *No one except a spouse* should unconditionally be allowed to make online purchases

Children in elementary school

- Elementary-school-age *children* should *never* be able to use capabilities *without supervision*

Visitors (babysitters, neighbors, and visiting family)

- *Visitors* should only be able to use any capabilities *while in the house*
- *Visitors* should *never* be allowed to use capabilities of *locks, doors, and cameras*
- *Babysitters* should only be able to *adjust the lighting and temperature*

Findings

- Context matters
  - Age: most influential factor
  - Location of device
  - Recent usage history
  - Time of day

A lot of contextual factors are beyond what an app / privacy assistant would know!

Findings

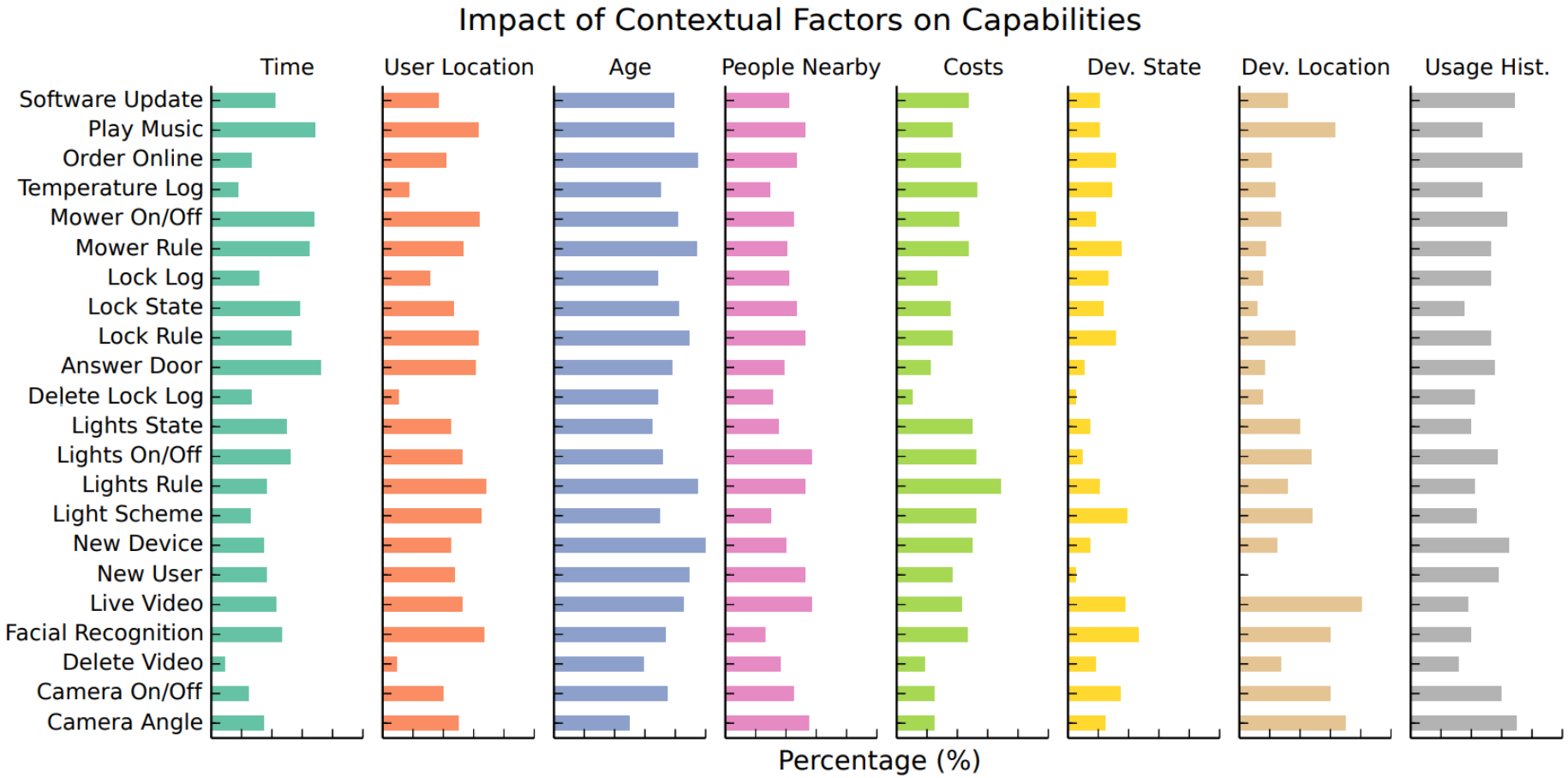
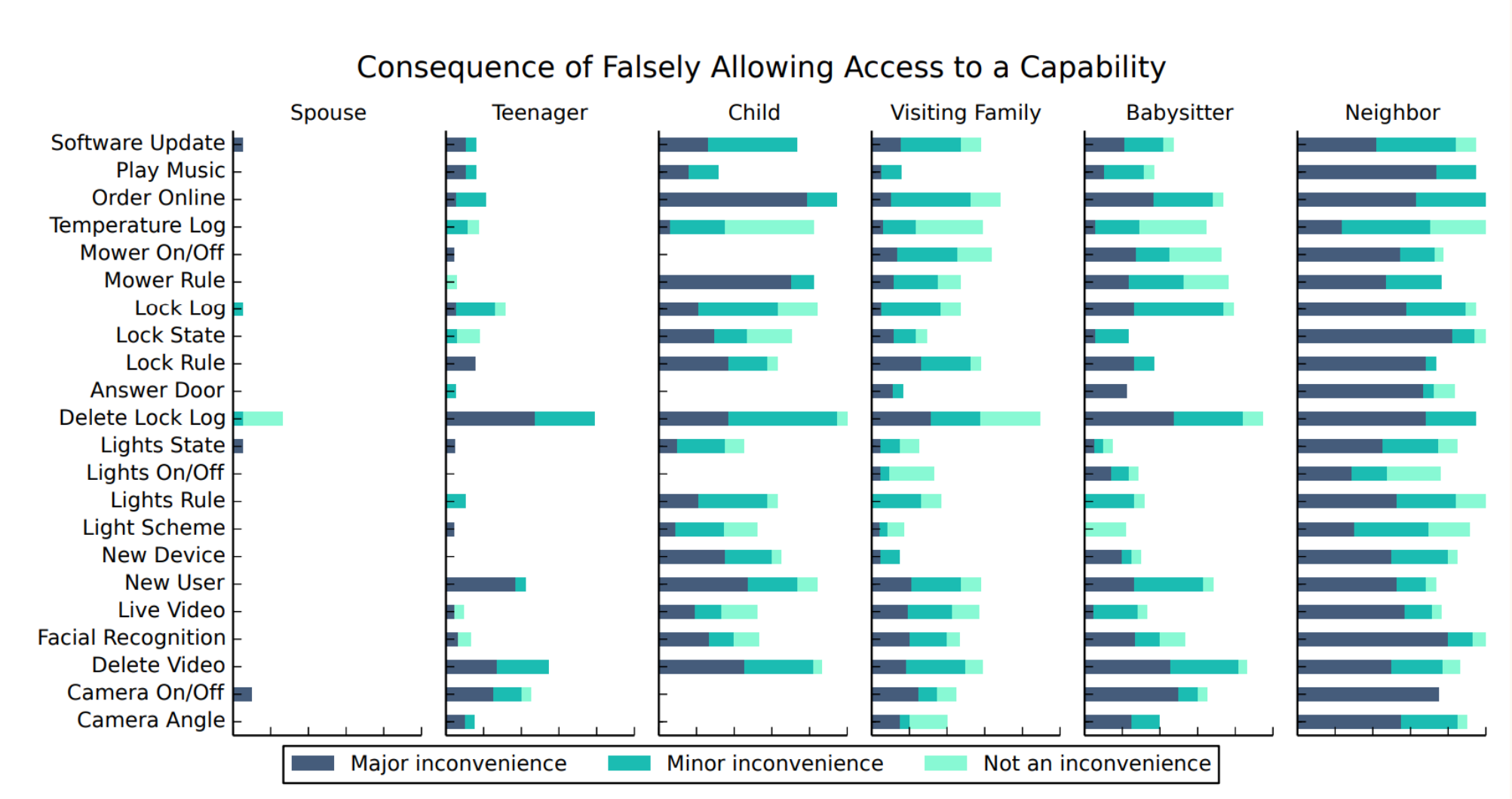
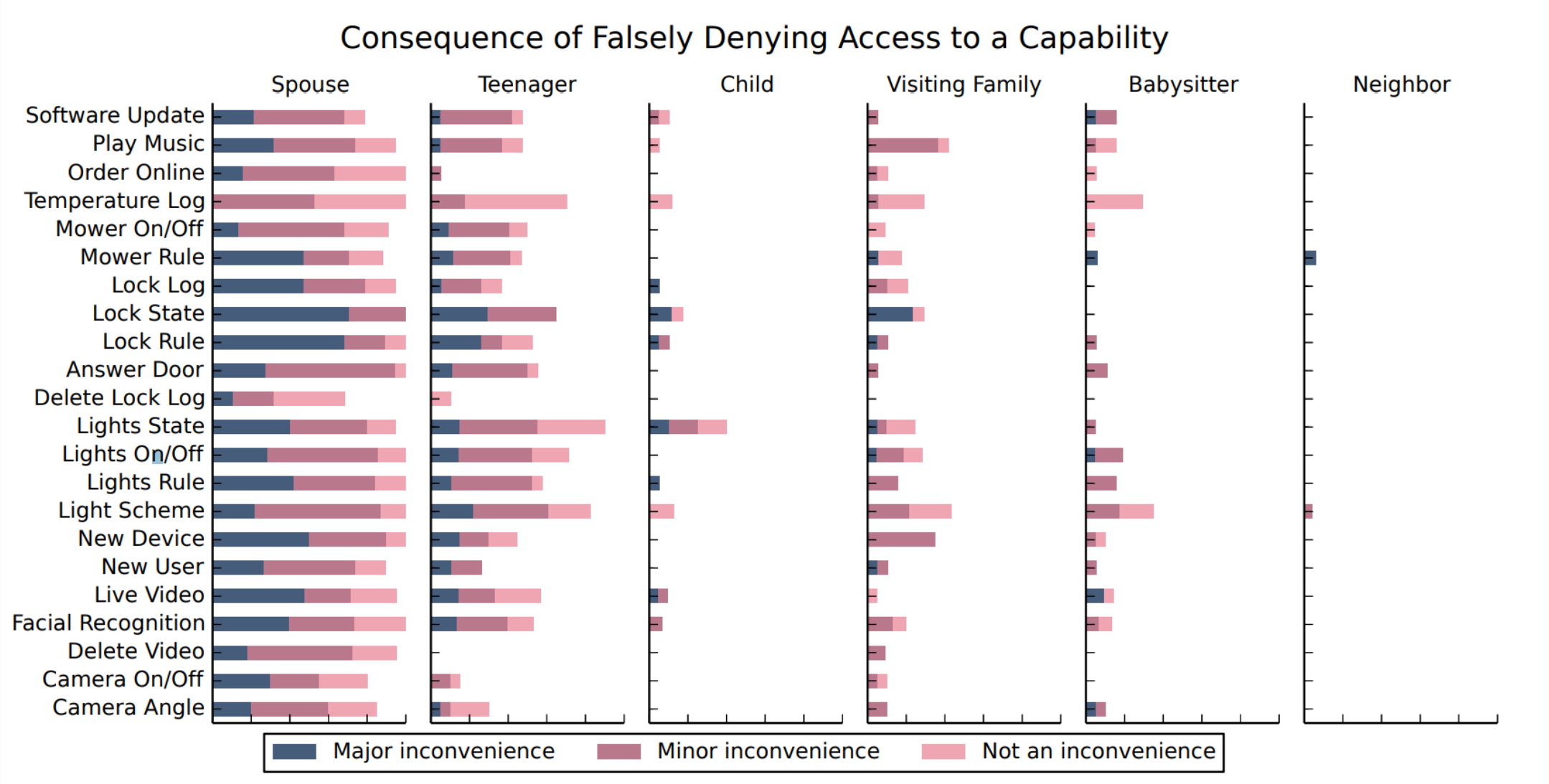


Figure 3: Contextual factors: Sometimes access must depend on the context. In the study we asked participants for such factors and identified multiple that are very influential (such as the age of the user) and learned how they contribute to the decision make process.

Findings


Consequence of Falsely Allowing Access to a Capability
Spouse
Teenager
Child
Visiting Family
Babysitter
Neighbor
Software Update
Play Music
Order Online
Temperature Log
Mower On/Off
Mower Rule
Lock Log
Lock State
Lock Rule
Answer Door
Delete Lock Log
Lights State
Lights On/Off
Lights Rule
Light Scheme
New Device
New User
Live Video
Facial Recognition
Delete Video
Camera On/Off
Camera Angle
Major inconvenience
Minor inconvenience
Not an inconvenience

Findings


Consequence of Falsely Denying Access to a Capability
Spouse
Teenager
Child
Visiting Family
Babysitter
Neighbor
Software Update
Play Music
Order Online
Temperature Log
Mower On/Off
Mower Rule
Lock Log
Lock State
Lock Rule
Answer Door
Delete Lock Log
Lights State
Lights On/Off
Lights Rule
Light Scheme
New Device
New User
Live Video
Facial Recognition
Delete Video
Camera On/Off
Camera Angle
Major inconvenience
Minor inconvenience
Not an inconvenience

Take-home

- Malkin, N., Luo, A.F., Poveda, J. and Mazurek, M.L., 2022, December. Optimistic Access Control for the Smart Home. In IEEE Symposium on Security and Privacy (SP) (pp. 2112-2129), 2023
- The Conversation - Platforms supporting Ukrainian refugees must prioritise their safety – or risk exposing them to trafficking and exploitation