

SoK: MANAGING LONGITUDINAL PRIVACY OF PUBLICLY SHARED PERSONAL ONLINE DATA

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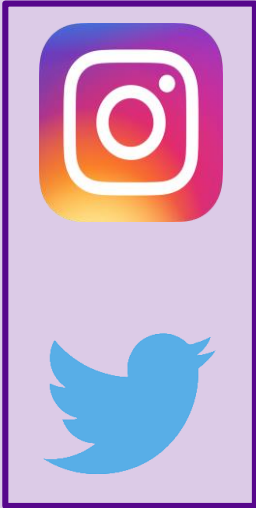
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MOTIVATION: LONGITUDINAL PRIVACY CONTROLS



1 165 320 photos

10 279 440 tweets

during this talk (18 minutes)

<https://www.internetlivestats.com/one-second/>

Are Privacy Controls Effective?

- Not meant to be permanent
→ Limited **data lifetime**
(Stories, Fleets)
- Not meant to be for everyone
→ Adjust **exposure control**
(Only share with followers)



RESEARCH ON LONGITUDINAL PRIVACY

HCI Perspective

- Reasons for Data Sharing
- Perception of Exposure
- Reasons for Unsharing

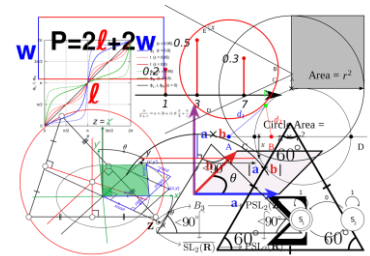
Technical Perspective

- Encrypted Publishing
- Expiration by Time
- No Threats During Data Lifetime



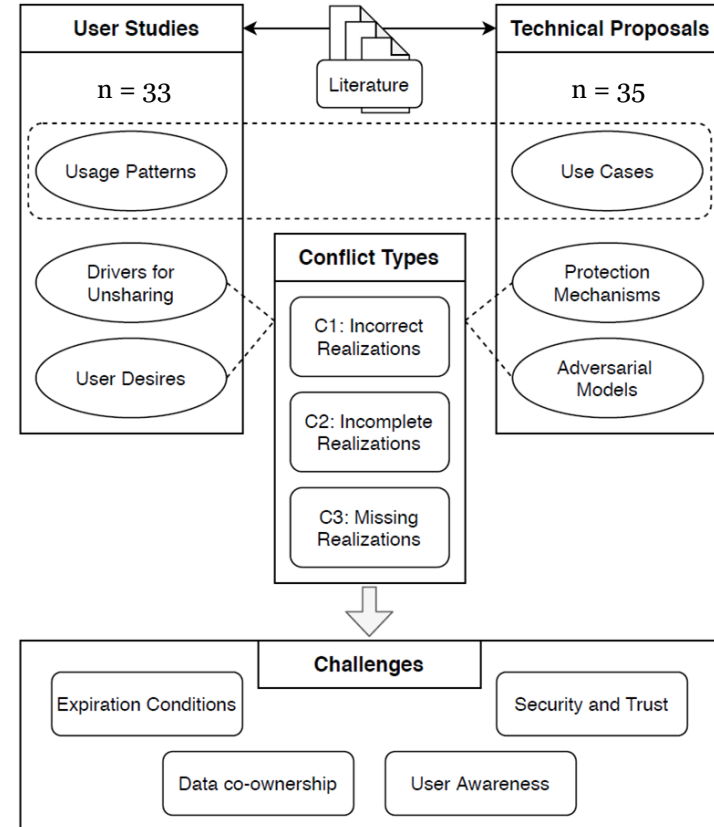
Goal of this SoK

Develop taxonomies and bring together both perspectives



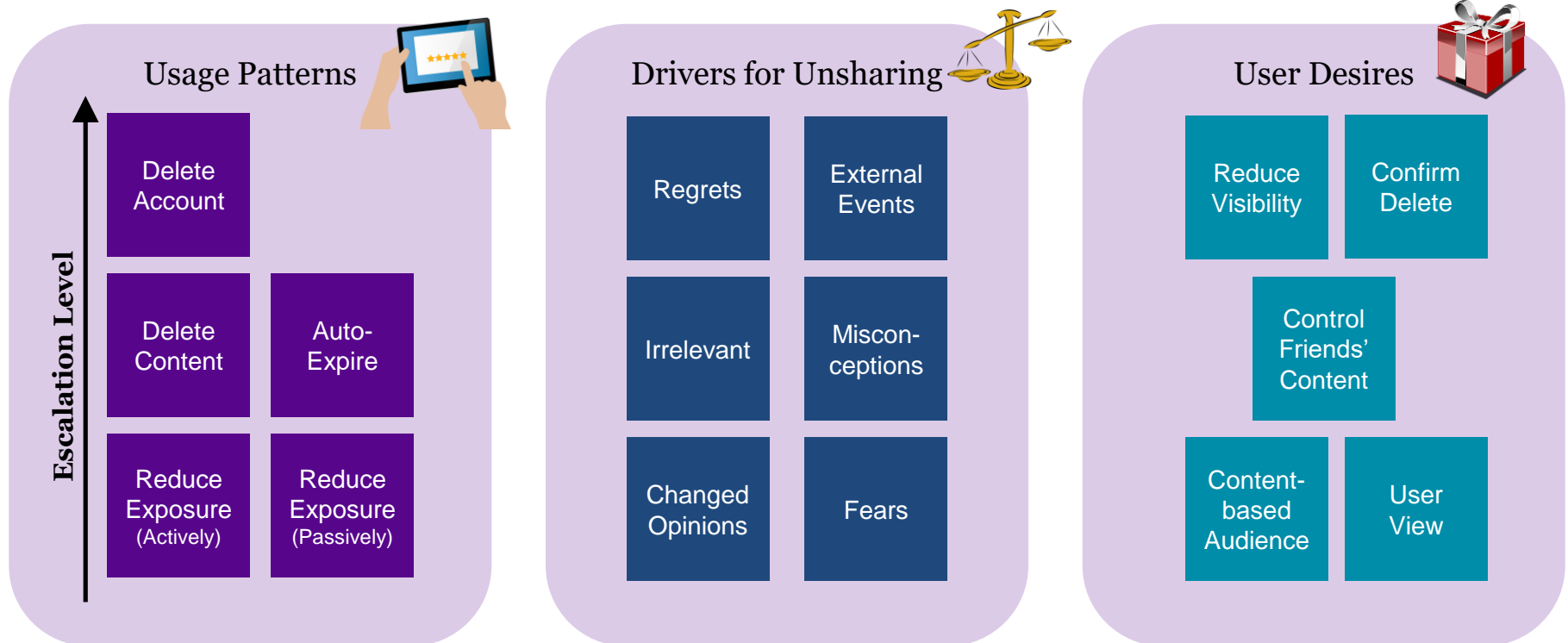
METHODOLOGY

- ❖ Survey of user studies & technical proposals
 - ❖ Categorization of user studies
 - ❖ Categorization of technical proposals
- ❖ Conflict identification
- ❖ Challenge derivation



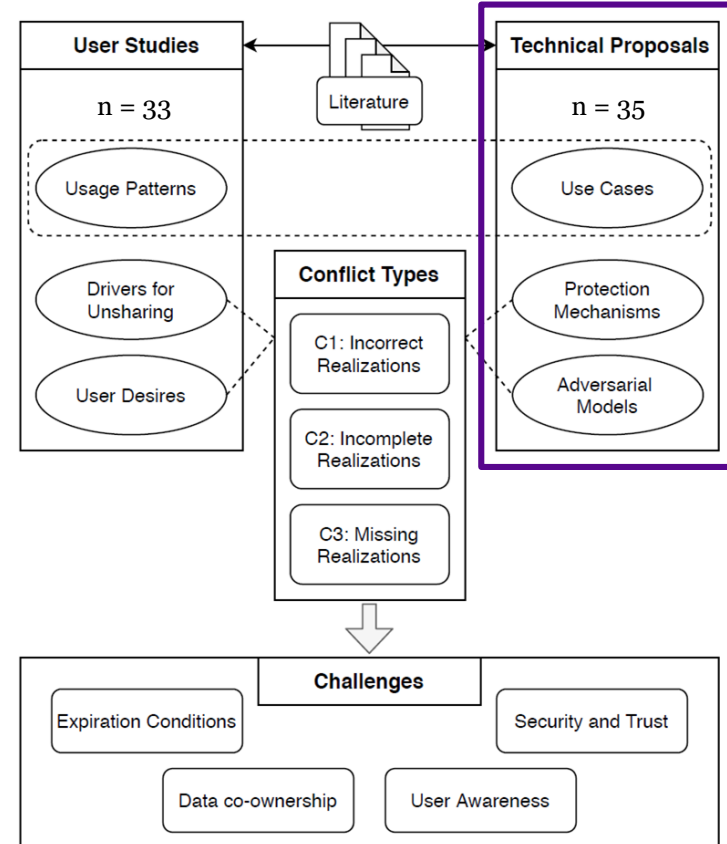


SYSTEMATIZATION OF USER STUDIES



METHODOLOGY

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SYSTEMATIZATION OF TECHNICAL PROPOSALS

Use Cases

User
Involvement

Number of
Data
Owners

Delete
Content

Reduce
Exposure

Adversarial Models

Retroactive

Curious

Interfering

Insider

Protection Mechanisms

Access
Control
Policies

Game
Theoretical

Adversarial
Examples

Deception &
Flooding

Crypto-
graphic

Distributed

SYSTEMATIZATION OF TECHNICAL PROPOSALS

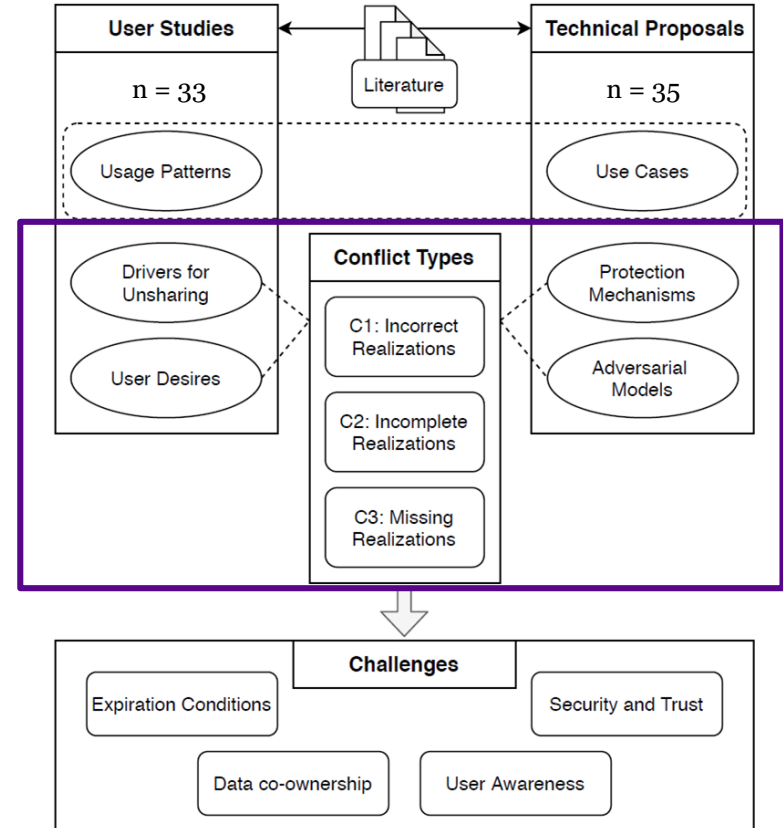
[52] Minaei et al. Lethe: Conceal Content Deletion from Persistent Observers. PETS'19.

[18] Cao & Yang. Towards Making Systems Forget with Machine Unlearning. S&P'15.

Publication		Use Cases		Adversarial Models				Underlying Protection Mechanisms									
Reference	Venue	Platform	Delete Content	Reduce Exposure	User Involvement	# of Data Owners	Retroactive	Honest-but-curious	Interfering	Insider	Cryptographic/Signatures	Distributed Architecture	Adversarial Examples	Deception & Flooding	Access Control Policies	Game-theoretical	Others/[Specifics]
[52]	PETS'19	TW	○	●	P	1	○	○	●	○	○	○	●	○	○		Intermittent withdrawal
[106]	ForensicSec'19	CL	○	●	P	n	○	●	●	○	●	○	○	●	○		[Attribute-based collaboration]
[82]	IFIP-SEC'19	PI	●	●	P	1	●	○	○	○	○	○	○	○	○		Smart contracts
[32]	NeurIPS'19	PI	●	○	P	1	●	○	○	○	○	○	○	○	○		Quantized k-means
[66]	NDSS'18	PI	○	●	A	n	○	●	●	○	●	○	●	○	○		Identity management system
[5]	CODASPY'18	PI	●	○	P	1	○	●	○	○	●	●	○	○	○		[Time-lock puzzles]
[38]	CODASPY'17	SN	○	○	P	n	○	○	○	●	●	○	○	●	○		[Threshold secret-sharing]
[65]	ICCV'17	SN	○	●	P	1	○	●	●	○	○	○	●	○	○		[Adversarial Image perturbations]
[58]	CVPR'17	SN	○	●	P	1	○	●	●	○	○	○	○	○	○		[Adversarial Image perturbations]
[74]	GameSec'17	SN	○	○	P	n	○	○	●	○	○	○	○	●	●		[Negotiation]
[104]	ETHReport'17	CL	●	○	A	n	○	○	●	●	●	○	○	○	○		[Group secret]
[7]	CCS'16	CL	●	●	A	1	●	●	○	○	●	○	○	○	○		Interdependency in encrypted
[108]	CODASPY'16	PI	●	○	P	1	●	○	○	○	●	●	○	○	○		[DNS Caching]
[95]	TKDE'16	SN	○	○	P	n	○	○	○	○	○	○	○	○	●		[Computational conflict resolution]
[18]	S&P'15	PI	●	○	P	1	●	○	●	○	○	○	○	○	○		Machine Unlearning
[64]	SIGMOD'15	PI	●	●	P	1	○	●	●	○	○	○	○	○	○		Brain-inspired data retention
[1]	ACM-SCC'15	CL	●	○	P	1	○	●	●	○	○	○	○	○	○		Forgetful data structures
[89]	CCSW'13	CL	○	○	P	1	○	○	○	○	●	○	○	○	○		Heterogeneous documents
[15]	NSPW'13	PI	○	○	A	1	○	○	○	●	○	○	●	○	○		[False attribution]
[93]	IEEE-PST'13	SN	○	○	A	n	●	●	○	○	●	○	○	○	○		User-to-content relations
[24]	S&P'12	TW	○	○	P	1	○	○	○	○	●	○	○	○	○		[Blind RSA signatures]
[79]	WPES'12	PI	●	○	P	1	●	○	○	○	●	○	○	○	○		Statistical webpage changes
[11]	PETS'11	SN	○	○	A	1	○	○	○	○	●	○	○	○	○		[OpenPGP]
[20]	ICNP'11	PI	●	○	P	1	●	○	○	○	●	●	○	○	○		[DNS Caching]
[31]	UW-CSE'11	PI	●	○	P	1	●	○	○	○	●	○	○	○	○		Integrating diverse mechanisms
[19]	CollbCom'11	SN	○	○	P	n	○	○	○	○	○	○	○	○	●		[Aggregation of policies]
[97]	PETS'10	SN	○	○	P	n	○	○	○	○	○	○	○	○	●		[Aggregation of policies]
[13]	CHI'10	FB	○	○	A	n	○	○	○	○	○	○	○	○	●		[Manual conflict resolution]
[105]	POLICY'10	SN	○	○	A	n	○	○	○	○	○	○	○	○	●		[Manual conflict resolution]
[72]	ACSAC'10	MA	●	○	P	1	○	○	○	○	●	○	○	○	○		Porter storage
[30]	USENIX'09	PI	●	○	P	1	●	○	○	○	●	○	○	○	○		[DHTs of P2P networks]
[91]	WWW'09	SN	○	○	P	n	○	○	○	○	○	○	○	○	●		Auction-based inference
[47]	CSE'09	SN	○	○	P	1	○	○	○	○	○	○	○	○	○		Third party storage server
[16]	SecureCom'09	PI	○	○	A	1	○	○	○	○	○	○	○	○	○		Bait information
[70]	SMLI'05	MA	●	○	P	1	●	○	○	○	●	○	○	○	○		[Centralized server storing keys]

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CONFLICT TYPES

User-centric approach: Reflection of **user desires** and their **drivers for unsharing** in technical proposals

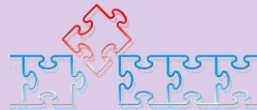
Incorrect Realization

Realizations in technical proposals that are orthogonal to users' desires



Incomplete Realization

Realizations that are promising but far from satisfying users' desires



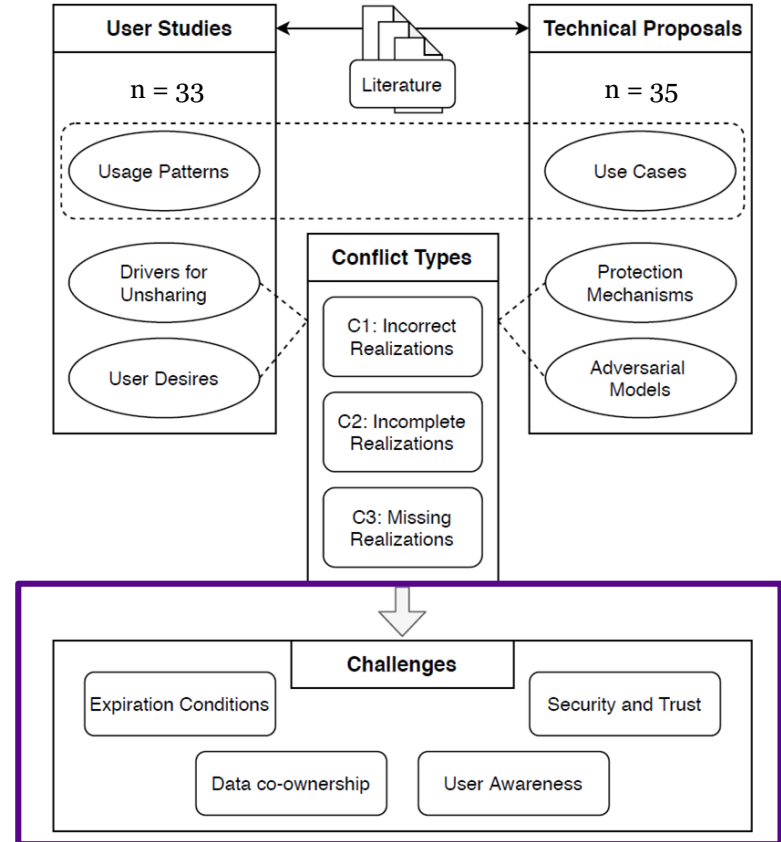
Missing Realization

User desires that are not addressed by technical solutions at all



METHODOLOGY

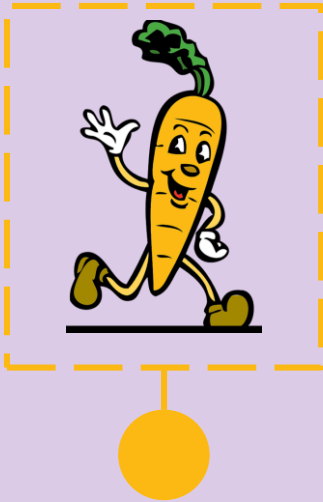
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EXPIRATION CONDITIONS

Scenario



Time based Expiration

- Lack of flexibility
- Appropriate time for revocation?

Difficult to predict in advance

No Expiration Condition

- Major life events
- Inactivity of the post
- Content's sensitivity could evolve

Flexible, nuanced expiration conditions may be required



EXPIRATION CONDITIONS

User Studies

- Lack of desire for content to fade away wholesale with age
Bauer et al., WPES'13 [9]
Khan et al., CHI'18 [41]
- Desire to incorporate interactions of the posts
Mondal et al., SOUPS'16 [54]
- Audience related considerations on per post basis
Habib et al., CHI'19 [35]

Technical Proposals

- Time passed since publication
Reimann et al., WPES'12 [79]
Geambasu et al., USENIX'09 [30]
- Interactions with content
Zarras et al., CODASPY'16 [108]
- Implemented as an explicit feature



EXPIRATION CONDITIONS

CHALLENGE

Missing realization of deletion as a context-dependent, implicit feature

→ **Context-based Expiration**

CHALLENGE

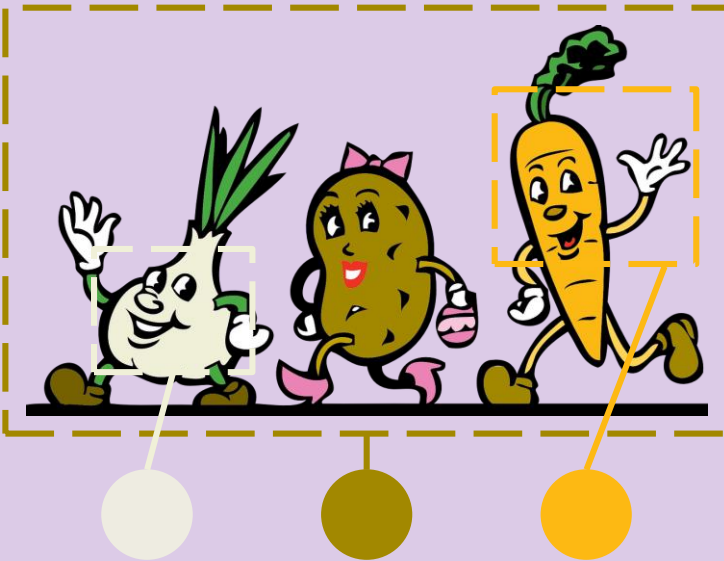
Incomplete realization of users' desire to **delete** data for certain **audiences**

→ **Audience-based Expiration**



DATA CO-OWNERSHIP

Scenario



What can happen?

- People can change their opinion
- Relationships can change

Adaptability of exposure may be required

Who can take action?

- Owner can remove the photo
- Others can remove their references

Power Imbalance between users



DATA CO-OWNERSHIP

User Studies

- Mitigation strategies
 - Untagging
Dhir et al., J.Comp. Hum. Beh.'16 [25]
 - Not taking photos at all
Rashidi et al., SOUPS'18 [77]
 - Revisiting privacy settings
Johnson et al., SOUPS'12 [39]
Madejski et al., PERCOM'12 [48]
- Desire to control friends' contents
Besmer et al., CHI'10 [13]

Technical Proposals

- Collaborative privacy controls
Squicciarini et al., WWW'09 [91]
Wishart et al., POLICY'10 [105]
- Voting mechanisms
Carminati et al., CollaborateCom'11 [19]
Thomas et al., PETS'10 [97]
- Automated resolution
Such et al., TKDE'16 [95]
- Opt-in for exposure
Olteanu et al., NDSS'18 [66]



DATA CO-OWNERSHIP

CHALLENGE

Missing realization of users' desire to **control their friends' content** wrt. the **adaptability** of exposure controls

→ **Adaptability**

CHALLENGE

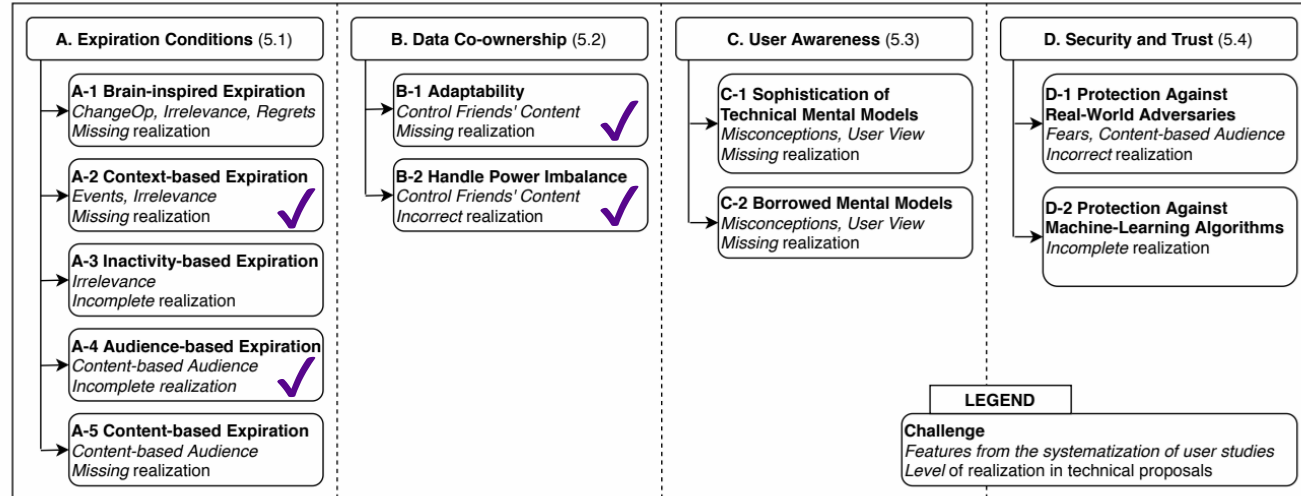
Incorrect realization of users' desire to **control their friends' content** wrt. **power imbalance** between users

→ **Handling Power Imbalance**



IN THE PAPER

- ❖ More Challenges
 - ❖ User Awareness
 - ❖ Security and Trust
- ❖ Further Issues
 - ❖ Metadata
 - ❖ Privacy Paradox
 - ❖ ... and more






Theodor Schnitzler^{†*}, Shujaat Mirza[†], Markus Dürmuth, and Christina Pöpper

SoK: Managing Longitudinal Privacy of Publicly Shared Personal Online Data

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Key Takeaways

- ❖ New Taxonomy for Managing Longitudinal Privacy in Online Social Networks
- ❖ Conflicts between User Interaction and Technical Proposals
- ❖ Challenges and Open Questions for Future Research on Data Revocation