Relationship-based Access Control for Online Social Networks: Beyond User-to-User Relationships

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Outline

• Motivation
• Model Components
• Model
• Use Cases
• Conclusions
Relationship-based Access Control

• Users in Online Social Networks (OSNs) are connected with social relationships (user-to-user relationships)

• Owner of the resource can control its release based on such relationships between the access requester and the owner
Sharings in Online Social Networks

• Online Social Networks provide services to promote information sharing by utilizing user activity information and shared contents.

• Users share information with other users
  – A user creates information to share with other users.
  – A user sends information to other users. (e.g., poke, invite)
  – A user receives information from/about other users.
  – Information about a user’s sharing activity is shared.

• Both resource and user as a target of sharing activity
  – Alice pokes bob
Controls in Online Social Networks

• A user wants to control other users’ access to her own shared information
  – Only friends can read my post
• A user wants to control other users’ activities who are related to the user
  – My children cannot be a friend of my co-workers
  – My activities should not be notified to my coworkers
• A user wants to control her outgoing/incoming activities
  – No accidental access to violent contents
  – Do not poke me

• A user’s activity influences access control decisions
  – Once Alice sends a friend request to Bob, Bob can see Alice’s profile
U2U Relationship-based Access Control (UURAC) Model

- **UA**: Accessing User
- **UT**: Target User
- **UC**: Controlling User
- **RT**: Target Resource
- **AUP**: Accessing User Policy
- **TUP**: Target User Policy
- **TRP**: Target Resource Policy
- **SP**: System Policy

- **Policy Individualization**
- **User and Resource as a Target**
- **Separation of user policies for incoming and outgoing actions**
- **Regular Expression based path pattern w/ max hopcounts (e.g., <ua, (f*c,3)>)**
Limitation of U2U Relationships

• We rely on the controlling user and ownership to regulate access to resources in UURAC (U2U Relationship-based AC)

• Needs more flexible control
  – Parental control, related user’s control (e.g., tagged user)
  – User relationships to resources (e.g., U-U-R)
  – User relationships via resources (e.g., U-R-U)
Beyond U2U Relationships

• There are various types of relationships between users and resources in addition to U2U relationships and ownership — e.g., share, like, comment, tag, etc

• U2U, U2R and R2R

• U2R further enables relationship and policy administration
Access Scenarios

Access in OSNs

User as Target

Resource as Target

Entity on the path

(b) Taxonomy based on Entity on the path

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Related Works

• Access Control Models for OSNs

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<tbody>
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<td>Multiple Relationship Types</td>
<td>✓</td>
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<td>Directional Relationship</td>
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<td>U2U Relationship</td>
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<td>U2R Relationship</td>
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</tbody>
</table>

| Model Characteristics          | ✓         | ✓             | ✓             | ✓               | ✓     | ✓     |
| Policy Individualization       | ✓         | ✓             | ✓             | ✓               | ✓     | ✓     |
| User & Resource as a Target    | ✓         | ✓             | ✓             | ✓               | ✓     | ✓     |
| Outgoing/Incoming Action Policy| ✓         | ✓             | ✓             | ✓               | ✓     | ✓     |

| Relationship Composition       | 0 to 2 f, f of f | 0 to n exact type sequence | 1 to n path of same type | 1 to n exact type sequence | 0 to n path pattern of different types | 0 to n path pattern of different types, hop count skipping |

• The advantages of URRAC:
  – Path pattern of different relationship types and hop count skipping make policy specification more expressive
  – System-level conflict resolution policy
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URRAC Model Components

AU: Accessing User
AS: Accessing Session
TU: Target User
TS: Target Session
O: Object
P: Policy
PAU: Accessing User Policy
PAS: Accessing Session Policy
PTU: Target User Policy
PTS: Target Session Policy
PO: Object Policy
PP: Policy for Policy
PSys: System Policy

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Characteristics of URRAC in OSNs

• **Policy Individualization**
  – Users define their own privacy and activity preferences
  – Related users can configure policies too
  – Collectively used by the system for control decision

• **Policy Administration**
  – Policy and Relationship Management
  – Users specify policies for other users and resources

• **User-session Distinction**
  – A user can have multiple sessions with different sets of privileges
  – Especially useful in mobile and location-based applications

• **Relationship-based Access Control**
Social Networks

• Social graph is modeled as a directed labeled simple graph $G=<V, E, \Sigma>$
  – $V = U \cup R$, where $U$ is users and $R$ is resources
  – Edges $E$ as relationships
  – $\Sigma=\{\sigma_1, \sigma_2, \ldots, \sigma_n, \sigma_1^{-1}, \sigma_2^{-1}, \ldots, \sigma_n^{-1}\}$ as relationship types supported
URRAC Social Graph

Fig. 3. A Sample Social Graph
Action and Access Request

- $\text{ACT} = \{\text{act}_1, \text{act}_2, \ldots, \text{act}_n\}$ is the set of OSN supported actions

- Access Request $<s, \text{act}, T>$
  - $s$ tries to perform $\text{act}$ on $T$
  - Target $T \subseteq (2^{TU \cup R} - \emptyset)$ is a non-empty set of users and resources
    - $T$ may contain multiple targets
Authorization Policy

<table>
<thead>
<tr>
<th>Accessing User Policy</th>
<th>&lt;act, graphrule&gt;</th>
</tr>
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<tbody>
<tr>
<td>Accessing Session Policy</td>
<td>&lt;act, graphrule&gt;</td>
</tr>
<tr>
<td>Target User Policy</td>
<td>&lt;act⁻¹, graphrule&gt;</td>
</tr>
<tr>
<td>Target Session Policy</td>
<td>&lt;act⁻¹, graphrule&gt;</td>
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<tr>
<td>Object Policy</td>
<td>&lt;act⁻¹, graphrule&gt;</td>
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<tr>
<td>Policy for Policy</td>
<td>&lt;act⁻¹, graphrule&gt;</td>
</tr>
<tr>
<td>System Policy for User</td>
<td>&lt;act, graphrule&gt;</td>
</tr>
<tr>
<td>System Policy for Resource</td>
<td>&lt;act, o.type, graphrule&gt;</td>
</tr>
</tbody>
</table>

• *action⁻¹* in TUP, TSP, OP and PP is the passive form since it applies to the recipient of action
• SP does not differentiate the active and passive forms
• SP for resource needs *o.type* to refine the scope of the resource

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Graph Rule Grammar

\[
\begin{align*}
\text{GraphRule} &\rightarrow "(" \text{StartingNode}" , " PATHRule" ")", \\
\text{PATHRule} &\rightarrow \text{PathSpecExp} | \text{PathSpecExp Connective PathRule} \\
\text{Connective} &\rightarrow \lor | \land \\
\text{PathSpecExp} &\rightarrow \text{PathSpec} | "-" \text{PathSpec} \\
\text{PathSpec} &\rightarrow "(" \text{Path}" , " HopCount" ")" | "(" \text{EmptySet}" , " HopCount" ")" \\
\text{HopCount} &\rightarrow \text{Number} \\
\text{Path} &\rightarrow ["[" \text{TypeSeq}" "]" | "]" \text{TypeSeq}" , " HopCount" "]" | "]" ["[" \text{TypeSeq}" , " HopCount" "]"] \\
\text{EmptySet} &\rightarrow \emptyset \\
\text{TypeSeq} &\rightarrow \text{TypeExp} \{"." \text{TypeExp}\} \\
\text{TypeExp} &\rightarrow \text{Specifier} | \text{Specifier Wildcard} \\
\text{StartingNode} &\rightarrow u_a | u_c | t \\
\text{Specifier} &\rightarrow \sigma_1 | \sigma_2 | \ldots | \sigma_n | \sigma_1^{-1} | \sigma_2^{-1} | \ldots | \sigma_n^{-1} | \Sigma \text{ where } \Sigma = \{\sigma_1, \sigma_2, \ldots, \sigma_n, \sigma_1^{-1}, \sigma_2^{-1}, \ldots, \sigma_n^{-1}\} \\
\text{Wildcard} &\rightarrow "*" | "?" | " + " \\
\text{Number} &\rightarrow [0 \ldots 9] +
\end{align*}
\]
Hopcount Skipping

- Six degrees of separation
  - Any pair of persons are distanced by about 6 people on average. (4.74 shown by recent study)
  - Hopcount for U2U relationships is practically small
- U2R and R2R relationships may form a long sequence
  - Omit the distance created by resources
  - Local hopcount stated inside “[]” will not be counted in global hopcount.
  - E.g., “([f*,3][[c*, 2]],3)”, the local hopcount 2 for c* does not apply to the global hopcount 3, thus allowing f* to have up to 3 hops.
Policy Conflict Resolution

• System-defined conflict resolution for potential conflicts among user-specified policies

• Disjunctive, conjunctive and prioritized order between relationship types
  – $\wedge, \vee, >$ represent disjunction, conjunction and precedence
  – $@$ is a special relationship “null” that denotes “self”
Policy Conflict Resolution (cont.)

\(< \text{read}^{-1}, (\text{own } \land \text{tag}) >\)

The more rigid one between the owner’s and the tagged users’ “\(\text{read}^{-1}\)” policies over the photo is honored.

\(< \text{friend_request}, (\text{parent} > \@) >\)

When child attempts friendship request to someone, parents’ policies get precedence over child’s own will.

\(< \text{share}^{-1}, (\text{own } \lor \text{tag } \lor \text{share}) >\)

A weblink is sharable if either the original owner, or any of the tagged users or shared users allows.
Access Evaluation Procedure

• Policy Collecting
  – To authorize \(<s, \text{act}, T>\), we need the following policies:
    • \(s\)'s session policy about \(\text{act}\)
    • a collection of \(\text{act}^{-1}\) policies from each target in \(T\)
    • system policies over \(\text{act}\) and \(\text{object type}\), if target is an object
Policy Extraction

• Policy: `<action, rule), graph rule>

• Graph Rule: `start, path rule`

• Path Rule: `path spec Λ | V path spec`

• Path Spec: `path, hopcount`

It determines the starting node, where the evaluation starts.

If `s` is `start`, then every `t` in `T` (and `uₖ`) becomes the evaluating node; otherwise, `s` is the evaluating node.

Path-check each path spec using Algorithm 2 in Cheng et al [11]

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Policy Evaluation

• Evaluate a combined result based on conjunctive or disjunctive connectives between path specs

• Make a collective result for multiple policies in each policy set.
  – Policy conflicts may arise. We apply $CRP_{Sys}$ to resolve conflicts.

• Compose the final result from the result of each policy set ($P_{AS}, P_{TU}/P_{TS}/P_{O}/P_{P}, P_{Sys}$)
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Example

- View a photo where a friend is tagged. *Bob and Ed are friends of Alice, but not friends of each other. Alice posted a photo and tagged Ed on it. Later, Bob sees the activity from his news feed and decides to view the photo: (Bob, read, Photo2)*
  - Bob’s $P_{AS}(read): <read, (u_a, ([\Sigma u_u^*, 2][[\Sigma u_r, 1]], 2)>$
  - Photo2’s $P_O(read^{-1})$ by Alice: $<read^{-1}, (t, ([post^{-1}, 1][friend^*, 3], 4))>$
  - Photo2’s $P_O(read^{-1})$ by Ed: $<read^{-1}, (u_e, ([friend], 1))>$
  - $AP_{sys}(read): <read, (ua, ([\Sigma u_u^*, 5][[\Sigma u_r, 1]], 5)>$
  - $CRP_{sys}(read): <read^{-1}, (own \land \text{tag})>$
Example (cont.)

• **Parental control of policies.** The system features parental control such as allowing parents to configure their children’s policies. The policies are used to control the incoming or outgoing activities of children, but are subject to the parents’ will. For instance, *Bob’s mother Carol requests to set some policy, say Policy1 for Bob: (Carol, specify policy, Policy1)*

  – Carol’s $P_{AS}(\text{specify\_policy})$: $<\text{specify\_policy}, (u_\omega([own], 1) \lor ([child\cdot own], 2))>$
  – Policy1’s $P_p(\text{specify\_policy}^{-1})$ by Bob: $<\text{specify\_policy}^{-1}, (t, ([own^{-1}], 1))>$
  – $P_{Sys}(\text{specify\_policy})$: $<\text{specify\_policy}, (u_\omega([own], 1) \lor ([child\cdot own], 2))>$
  – $CRP_{Sys}(\text{specify\_policy})$: $<\text{specify\_policy}, (parent \land @)>$
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Summary

• Proposed a U2U, U2R and R2R relationship-based access control model for users’ usage and administrative access in OSNs
  — Access control policies are based on regular expression based path patterns
  — Hopcount skipping for more expressiveness
• Provided a system-level conflict resolution policies based on relationship precedence
Future Work

• Incorporate attribute-based controls
• Extend DFS-based path checking algorithm to cover U2R and R2R relationships
• Undertake performance and scalability tests
Questions?