# Privacy Preserved Meeting Scheduling

Group 06

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## 1 Tentative basic definitions

Following finite sets are defined:

- $\mathcal{D}$: The set of all documents.
- $\mathcal{R}$: The set of all roles.
- $\mathcal{I}$: The set of all individuals
- $\mathcal{L}$: The set of all locations.
- $\mathcal{T}$: The set of all time slots.

Following functions are also defined:

$$access : \mathcal{D} \mapsto 2^{\mathcal{R}} (2^{\mathcal{R}} = \text{power set of } \mathcal{R})$$

$$access(d) = \{r \in \mathcal{R} \mid r \text{ has access to } d\}$$

$$transform : \mathcal{I} \times \mathcal{L} \times \mathcal{T} \mapsto \mathcal{R}$$

$$transform(i, l, t) = r : r \text{ is role of } i \text{ at location } l \text{ at time slot } t$$

$$location : \mathcal{I} \times \mathcal{T} \mapsto \mathcal{L}$$

$$location(i, t) = l : i \text{ is at } l \text{ at } t$$

A meeting M is a 4-tupple,

$$M =< D, I, L, t >$$

such that,

$$D \subseteq \mathcal{D}$$

$$L \subseteq \mathcal{L}$$

$$I \subseteq \mathcal{I}$$

$$t \in \mathcal{T}$$

## 2 Access Control List

Consider that following finite sets are defined:

- $\mathcal{D}$: The set of all documents.
- $\mathcal{I}$: The set of all individuals

Based on those 2 sets, we define following 2 relationships.

$$d = \{d \in \mathcal{D} \mid \text{d is a document}\}$$

$$access(d) = \{i \in \mathcal{I} \mid i \text{ has access to } d\}$$

They mean that $d$ is an element is set $\mathcal{D}$, and that $access(d)$ is the set of individuals ($i$) having access permission to document $d$.
By 2$^{\text{nd}}$ relationship, since any element $i$ of $access(d)$ is also an element of $I$, we obtain the relationship $access(d) \subseteq \mathcal{I}$. Accordingly, in case all individuals of set $I$ have access to particular document $d$, $access(d) = I$.
We define any $d$ such that $access(d) = I$ as a **public document**.

## 3 Definition of a meeting

Consider that following finite sets are also defined, other than sets defined above:

- $\mathcal{L}$: The set of all locations.
- $\mathcal{T}$: The set of all time slots.

**We assume that every meeting has an agenda associated with it, to define the set of individuals required to attend the meeting**. Agenda of a particular meeting $M$ is a document, belonging to set $\mathcal{D}$.
When we consider that agenda of meeting $M = d$, for every individual $i$ invited to meeting $M$; $i \in access(d)$. Also consider that, $D$ represents set of documents discussed in $M$, including agenda, such that $D \subseteq \mathcal{D}$. According to our assumption mentioned above, for any meeting $M$; $|D| \geq 1$.

For conducting a meeting, at least 2 individuals are required. Consider that $I$ represents the set of individuals attending meeting $M$, such that $I \subseteq \mathcal{I}$. Here we note that, for any meeting $M$; $|I| \geq 2$.

Consider set of locations of individuals in $M$ as $L$ (in other words, set of locations of indiduals in set $I$, during meeting time), such that $L \subseteq \mathcal{L}$. Every individual attends meeting from a particular location $l$, such that $l \in L$. We note that if meeting is online or hybrid, $|L| > 1$. If meeting is onsite, $|L| = 1$, since every individual is at same location. $\therefore$ For any meeting $M$; $|L| \geq 1$.

Since a **meeting** is a **synchrnous** communication, every individual in meeting $M$ should attend the meeting during the same time slot $t$ (Assuming that all individuals are in same time zone).

Based on these definitions, we define meeting M as a 4-tupple,

$$M =< D, I, L, t >$$

such that,

$$D \subseteq \mathcal{D}$$

$$L \subseteq \mathcal{L}$$

$$I \subseteq \mathcal{I}$$

$$t \in \mathcal{T}$$

# 4 Transformation of individual into role

Consider that same sets defined above will be used in explanations below, in same notations:

Consider $i$ and $i'$ as individuals such that $i, i' \in \mathcal{I}$. And consider $d$ as a document , $l$ as a location and $t$ as a time slot such that $d \in \mathcal{D}$, $l \in \mathcal{L}$ and $t \in \mathcal{T}$. Further consider that $i \in access(d)$ and $i' \notin access(d)$, for restricting access of document $d$, where $|access(d)| = n$ and $access(d) \neq I$.

Assume that at scenario 1, $i$ attends a **meeting** at location $l$ during time slot $t$ to discuss document $d$, where $i'$ has no access to location $l$ during same time slot $t$.
Here we state that privacy of meeting discussing document $d$ was preserved at context $l \times t$

Now assume that at scenario 2, $i$ attends a **meeting** at location $l$ during time slot $t$ to discuss document $d$, where $i'$ also has access to location $l$ during same time slot $t$.
Here we state that privacy of meeting discussing document $d$ was violated at context $l \times t$, because $n + 1$ individuals including $i'$ have got access to content of document $d$. But actually $|access(d)| = n$ as mentioned above. We observe that $(n + 1) \geq |access(d)| = n$

When above 2 scenarios are compared, we observe that role of same individual $i$, such that $i \in access(d)$, has experienced a variation. Context of $i$ has changed, depending on location and time.

Therefore we define that presence of $i$ at context $l \times t$ transforms $i$ to role $(r)$, relative to document $d$, such that $r \rightarrow i, l, t, d$.

$transform(i, l, t, d) = r : r$ is role of $i$ at location $l$ at time slot $t$, relative to document $d$

If $i \in access(d)$ and $i' \notin access(d)$, $i$ should attend a meeting to discuss $d$ at context $l \times t$, only if $i'$ has no access to $l \times t$. Accordingly, to identify the privacy preserving context for discussing document $d$, combination of i, l, t is required.

# 5 Difference between public and private roles

We define $l \times t$ as a **private** context, relative to document $d$, if $i'$ such that $i' \notin access(d)$ has no access to $l \times t$. Using this definition and above formula, we can show that, $i$ such that $i \in access(d)$ is transformed to $i - private_d$ role, at a private context defined relative to document $d$.

$$transform(i, l, t, d) = r$$

$$transform(i, (private\_context), d) = r$$

$$transform(i, (private\_context), d) = i - private_d$$

On the other hand, we define $l \times t$ as a **public** context, relative to document $d$, if $i'$ such that $i' \notin access(d)$ has access to $l \times t$.
Using this definition and above formula, we can show that, $i$ such that $i \in access(d)$ is transformed to $i - public_d$ role, at a public context defined relative to document $d$.

$$transform(i, l, t, d) = r$$

$$transform(i, (public\_context), d) = r$$

$$transform(i, (public\_context), d) = i - public_d$$

Based on these derivations, we have identified a constraint relevant to $i$, for discussing $d$ in a privacy preserved meeting.

**Constraint**: Every $i$ such that $i \in access(d)$, that attends a meeting to discuss document $d$, should represent $i - private_d$ role in the meeting.

Relative to a public document ($access(d) = I$), every $l \times t$ context is a private context. Hence every $i$ represents $i - private_d$ role, irrespective of context. Therefore a public document can be discussed at any $l \times t$, without any restriction.

## 6 Variation of role

Now consider a situation where individual $i$ such that $i \in access(d)$ has $x$ number of locations, out of which any one can be selected for attending a meeting to discuss $d$. And assume that $i$ has $y$ number of time slots, out of which any one can be selected for attending the meeting.

We can depict the possible variations of $transform(i, l, t, d)$ function as below, for individual $i$, relative to document $d$, assuming that $i$ doesn't change location during middle of a time slot.

| $(i, d)$ | $t_1$ | $t_2$ | ... | $t_{y-1}$ | $t_y$ |
|---|---|---|---|---|---|
| $l_1$ | x | x | | x | x |
| $l_2$ | x | x | | x | x |
| ... | | | | | |
| $l_{x-1}$ | x | x | | x | x |
| $l_x$ | x | x | | x | x |

Table 1: Possibilities in variation of $transform(i, l, t, d)$ for individual $i$, relative to document $d$

Note that $l_x$ represents the $x^{th}$ location, while $t_y$ represents the $y^{th}$ time slot. Meanwhile x represents the role of $i$ at the corresponding $l$ and $t$, relative to $d$ (based on formula $transform(i, l, t, d) = r$). According to this representation, we observe that $i$ has $x \times y$ number of possibilities at maximum, to attain the role, relative to $d$.

Here we emphasize that each x can be categorized as $i - private_d$ or $i - public_d$, with respect to the document $d$, to be discussed. According to the constraint identified, $i$ should attend the meeting only when $r = i - private_d$. By following this constraint, access of $i'$ such that $i' \notin aceess(d)$, into this meeting can be prevented.

## 7 Meeting quorum

We define **meeting quorum** as minimum number of roles ($r$) required to discuss document $d$, such that $r \in access(d)$.

In *privacy preserved meeting* context, if a **meeting quorum** isn't defined for discussing $d$, we assume that every $r$ where $r \in access(d)$ is required to discuss document $d$. Therefore, $|meeting\ quorum| \leq |access(d)|$.

Since at least 2 roles ($r$) are required for discussing any document $d$, $2 \leq$

$|meeting\ quorum|$.

Accordingly, $2 \leq |meeting\ quorum| \leq |access(d)|$.

If every $r$ such that $r \in \mathcal{R}$, is in $access(d)$, $|access(d)| = |\mathcal{R}|$. It implies that $|access(d)| \leq |\mathcal{R}|$.

$\therefore 2 \leq |meeting\ quorum| \leq |access(d)| \leq |\mathcal{R}|$

In a *privacy preserved meeting*, if $r' \notin access(d)$, $r'$ shouldn't have access to $d$.

Regarding any document $d$, $\forall r \in access(d)$, we define the function,

$$transform(i, l, t) = r : r \text{ is role of } i \text{ at location } l \text{ at time slot } t$$

This shows that