

Keeping Evolving Requirements and Acceptance Tests Aligned with Automatically Generated Guidance

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Requirements
Engineering
Research
Group



Agenda

1. Context, background and motivation

2. Our approach and tool

3. Evaluation

4. Summary

Requirements and acceptance tests – an example

Requirement id: REQ1

Title: Group chat management – adding users to a group

Text: A user can add new users to the group. The addition of a new user must be first approved by the admin. The admin can modify personal data and the status of a user.

Test id: AT1

Title: Test for REQ1 (Group chat management – adding users to a group)

Prerequisites: Internet connection is needed.

Steps:

1. Log-in as user
2. Open the page with users' groups
3. Click on the button "Manage group" next to the Group 1.

...

Expected results:

Login is successful
The page is opened and the list of groups is visible
The group members are listed and there is a button "Add users" in the upper, right corner.

...

Motivation



Motivation



REQUIREMENTS CHANGE

Motivation



**TESTERS ARE
NOT AWARE**

REQUIREMENTS CHANGE

Motivation



**OUTDATED,
NON-ALIGNED
TESTS**

**TESTERS ARE
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REQUIREMENTS CHANGE

Motivation



**BUGS
FOR
FEATURES**

**OUTDATED,
NON-ALIGNED
TESTS**

**TESTERS ARE
NOT AWARE**

REQUIREMENTS CHANGE

Motivation

Motivation

Non-aligned documents



Motivation

Non-aligned documents



Poor communication



Motivation

Non-aligned documents



Poor communication



False expectations



Motivation

Non-aligned documents



Poor communication



False expectations



=>

Motivation

Non-aligned documents



Poor communication



False expectations



=>



Motivation

Non-aligned documents



Poor communication



False expectations



⇒



&



Motivation

Non-aligned documents



Poor communication



False expectations



⇒



&



&



State of the art

Keep software documentation aligned using
Information Retrieval and Natural Language Processing
methods for identifying impacted documents.

State of the art

Gaps in the current methods:

- Less applied between requirements and acceptance tests
- Only identify **which** documents are impacted by a change, but not suggest **how** to manage the change

The goals of our approach (GuideGen)

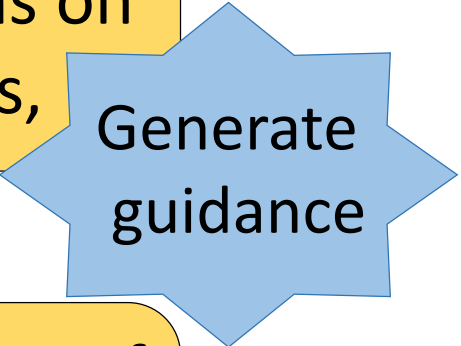
When requirements evolve:

1. Support test engineers in making decisions on how to modify impacted acceptance tests,
2. Ensure on-time and smooth communication of changes between requirements and test engineers.

The goals of our approach (GuideGen)

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Generate
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When requirements evolve:

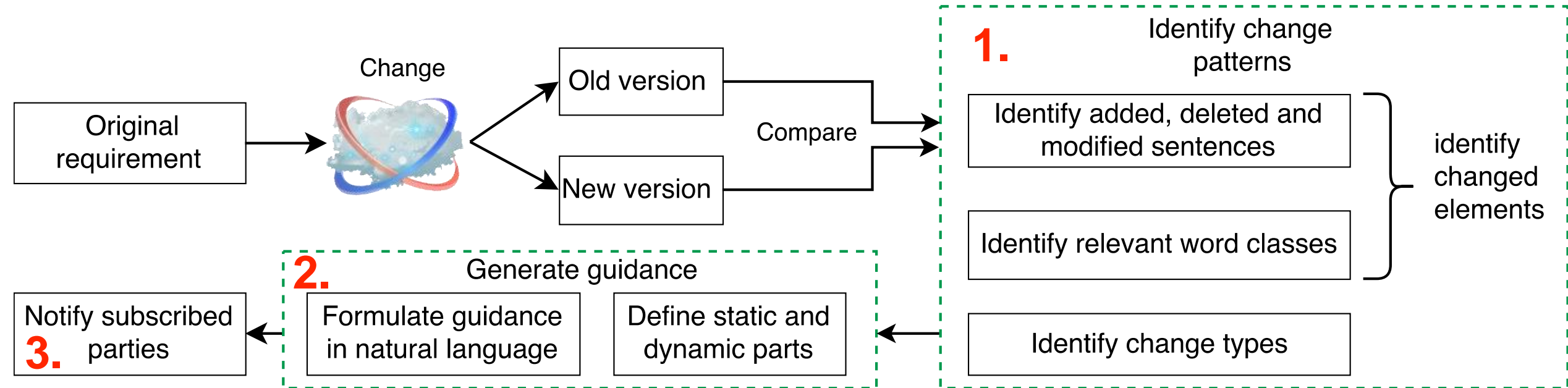
1. Support test engineers in making decisions on how to modify impacted acceptance tests,

Generate
guidance

2. Ensure on-time and smooth communication of changes between requirements and test engineers.

Notification
system

GuideGen overview



An example of requirement changes and generated suggestions

A user can add new users to the group.

~~The addition of a new user must be first approved by the admin.~~

The admin and the user can modify personal data ~~and the status~~ of that a user. Only user can modify its status. The admin must be logged-in in order to modify personal data of a user.

An example of requirement changes and generated suggestions

A user can add new users to the group.

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1. Delete steps or their parts which verify that the addition of a new user must be first approved by the admin.

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1. Delete steps or their parts which verify that the addition of a new user must be first approved by the admin.
2. Make sure that now the user can modify personal data of that user. Add the steps or modify the expected results which verify this activity.

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3. Delete steps or their parts which verify that the admin can modify the status of a user.
4. Add new steps or modify existing steps to verify that only user can modify its status.

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3. Delete steps or their parts which verify that the admin can modify the status of a user.
4. Add new steps or modify existing steps to verify that only user can modify its status.
5. Add new steps or modify existing steps to verify that the admin must be logged-in in order to modify personal data of a user.

1. Identify relevant change patterns – sentence level

The sentences in oldReq:

1. A user can add new users to the group.
2. The addition of a new user must be first approved by the admin.
3. The admin can modify personal data and the status of a user.

The sentences in newReq:

1. A user can add new users to the group.
2. The admin and the user can modify personal data of that user.
3. Only user can modify its status.
4. The admin must be logged-in in order to modify personal data of a user.

1. Identify relevant change patterns – sentence level

The sentences in oldReq:

Similarity Score (S):

The sentences in newReq:

1. A user can add new users to the group.

2. The addition of a new user must be first approved by the admin.

3. The admin can modify personal data and the status of a user.

1. A user can add new users to the group.

2. The admin and the user can modify personal data of that user.

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4. The admin must be logged-in in order to modify personal data of a user.

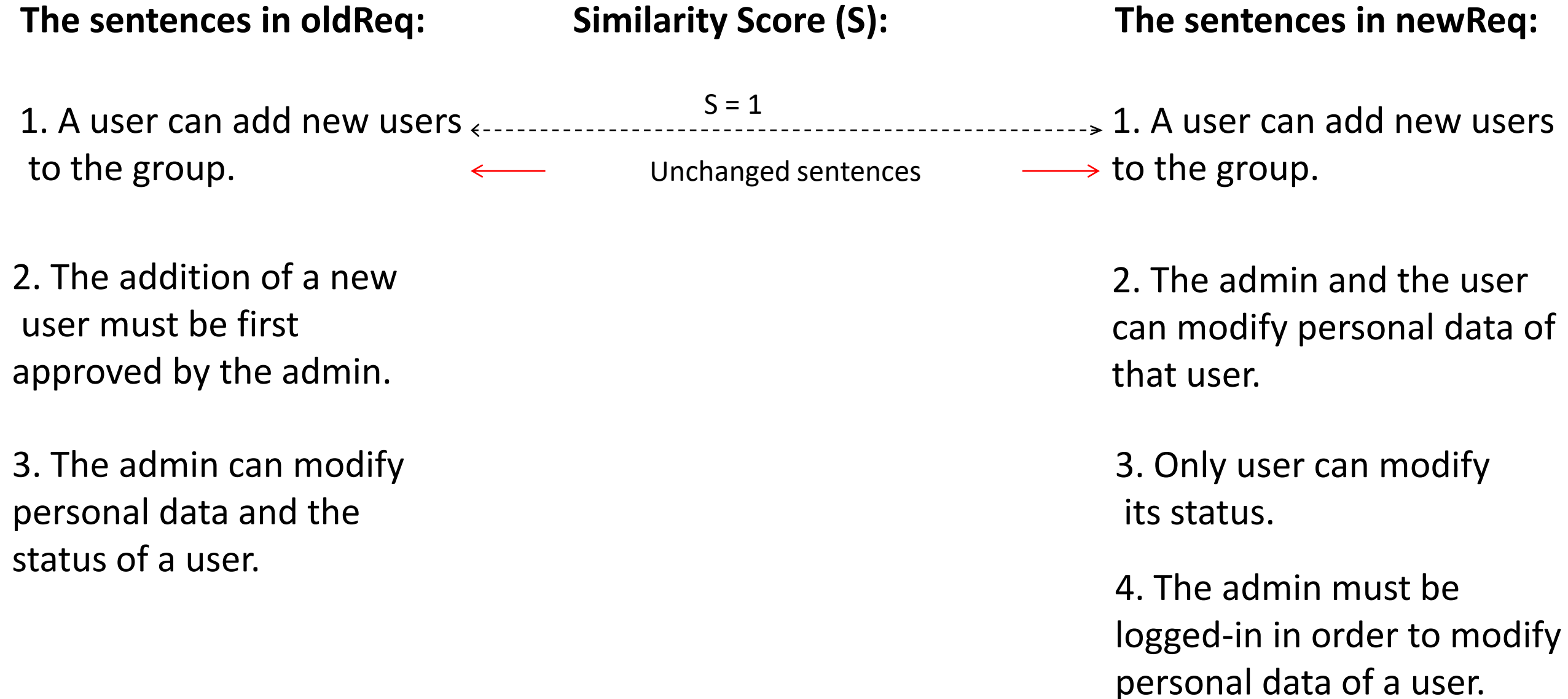
1. Identify relevant change patterns – sentence level

The sentences in oldReq:	Similarity Score (S):	The sentences in newReq:
1. A user can add new users to the group.	←-----→	1. A user can add new users to the group.
2. The addition of a new user must be first approved by the admin.		2. The admin and the user can modify personal data of that user.
3. The admin can modify personal data and the status of a user.		3. Only user can modify its status.
		4. The admin must be logged-in in order to modify personal data of a user.

1. Identify relevant change patterns – sentence level

The sentences in oldReq:	Similarity Score (S):	The sentences in newReq:
1. A user can add new users to the group.	$S = 1$	1. A user can add new users to the group.
2. The addition of a new user must be first approved by the admin.		2. The admin and the user can modify personal data of that user.
3. The admin can modify personal data and the status of a user.		3. Only user can modify its status.
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Similarity Score (S):

The sentences in newReq:

1. A user can add new users to the group.	$S = 1$ Unchanged sentences	1. A user can add new users to the group.
2. The addition of a new user must be first approved by the admin.		2. The admin and the user can modify personal data of that user.
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1. Identify relevant change patterns – sentence level

The sentences in oldReq:

Similarity Score (S):

The sentences in newReq:

1. A user can add new users to the group.

$S = 1$

Unchanged sentences

1. A user can add new users to the group.

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2. The admin and the user can modify personal data of that user.

3. The admin can modify personal data and the status of a user.

3. Only user can modify its status.

4. The admin must be logged-in in order to modify personal data of a user.

1. Identify relevant change patterns – sentence level

The sentences in oldReq:

Similarity Score (S):

The sentences in newReq:

1. A user can add new users to the group.

$S = 1$

Unchanged sentences

1. A user can add new users to the group.

2. The addition of a new user must be first approved by the admin.

$S = 0.36$

2. The admin and the user can modify personal data of that user.

3. The admin can modify personal data and the status of a user.

3. Only user can modify its status.

4. The admin must be logged-in in order to modify personal data of a user.

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2. The admin and the user can modify personal data of that user.

3. The admin can modify personal data and the status of a user.

$S = 0.11$

3. Only user can modify its status.

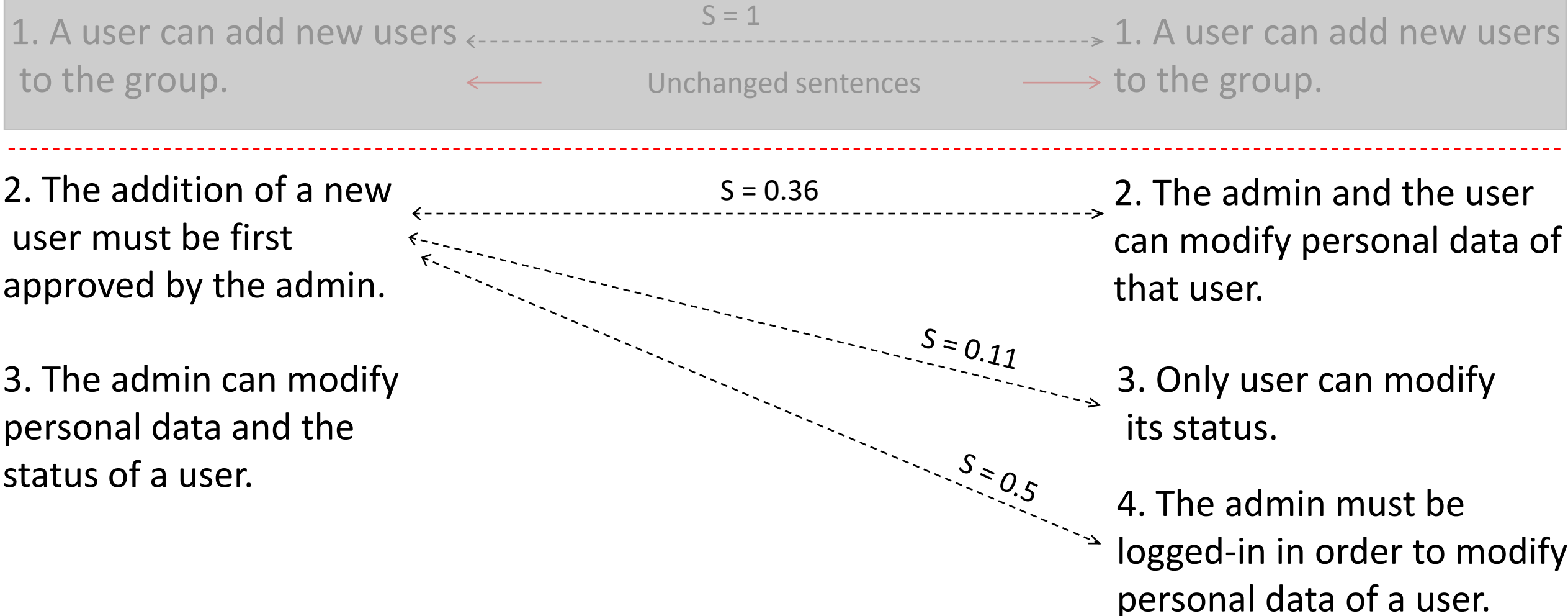
4. The admin must be logged-in in order to modify personal data of a user.

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1. Identify relevant change patterns – sentence level

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Unchanged sentences

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$S = 0.5$

4. The admin must be logged-in in order to modify personal data of a user.

Similarity threshold = 0.6

1. Identify relevant change patterns – sentence level

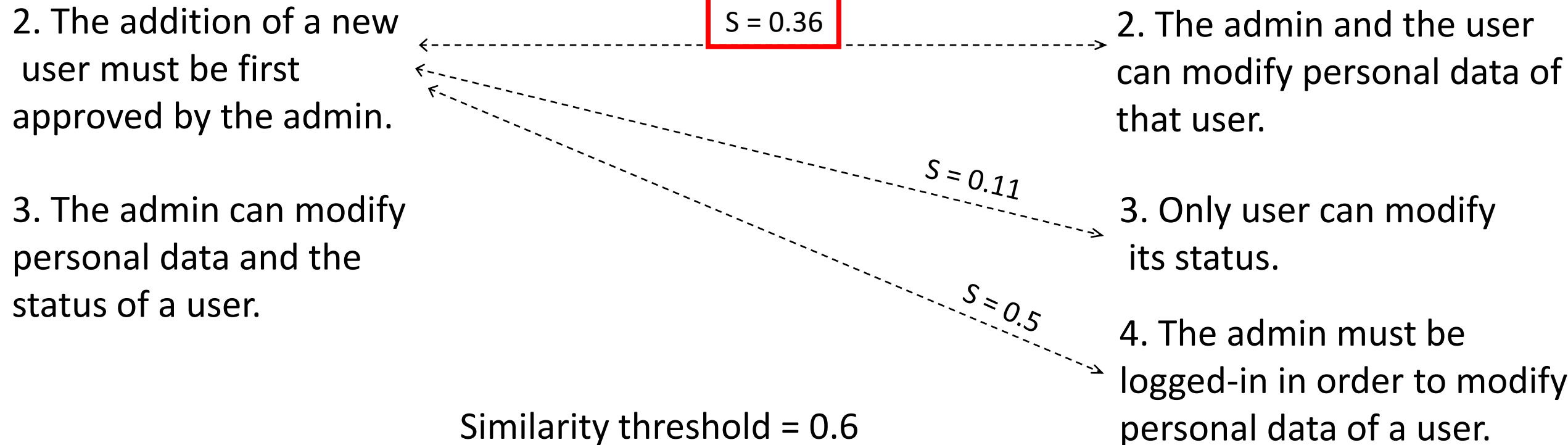
The sentences in oldReq:

Similarity Score (S):

The sentences in newReq:

1. A user can add new users to the group. $\xleftarrow{S=1}$ 1. A user can add new users to the group.

← Unchanged sentences →



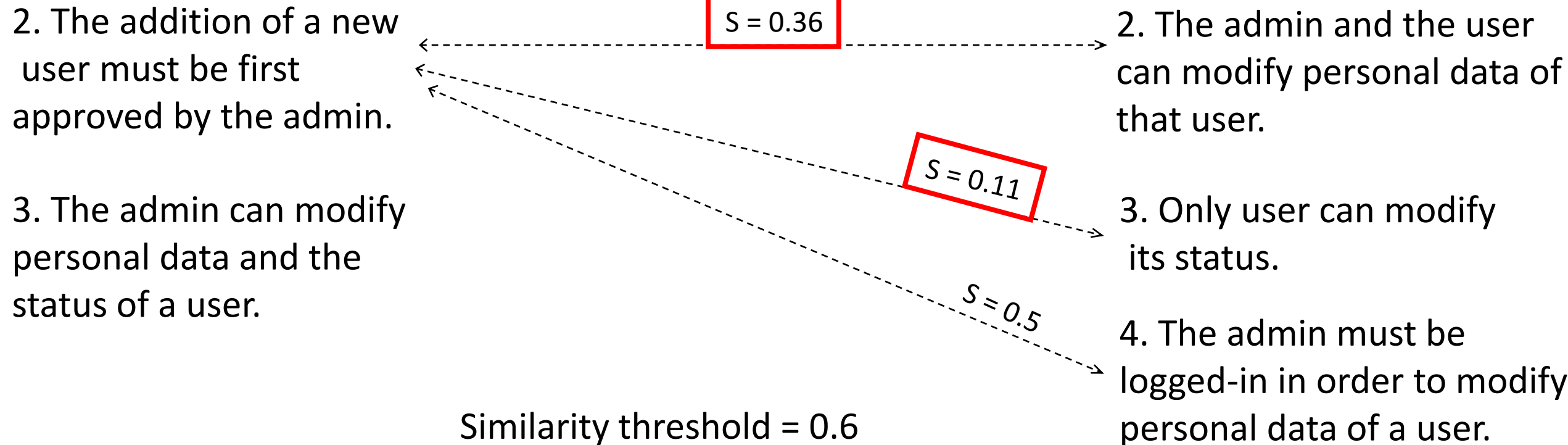
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Unchanged sentences



1. Identify relevant change patterns – sentence level

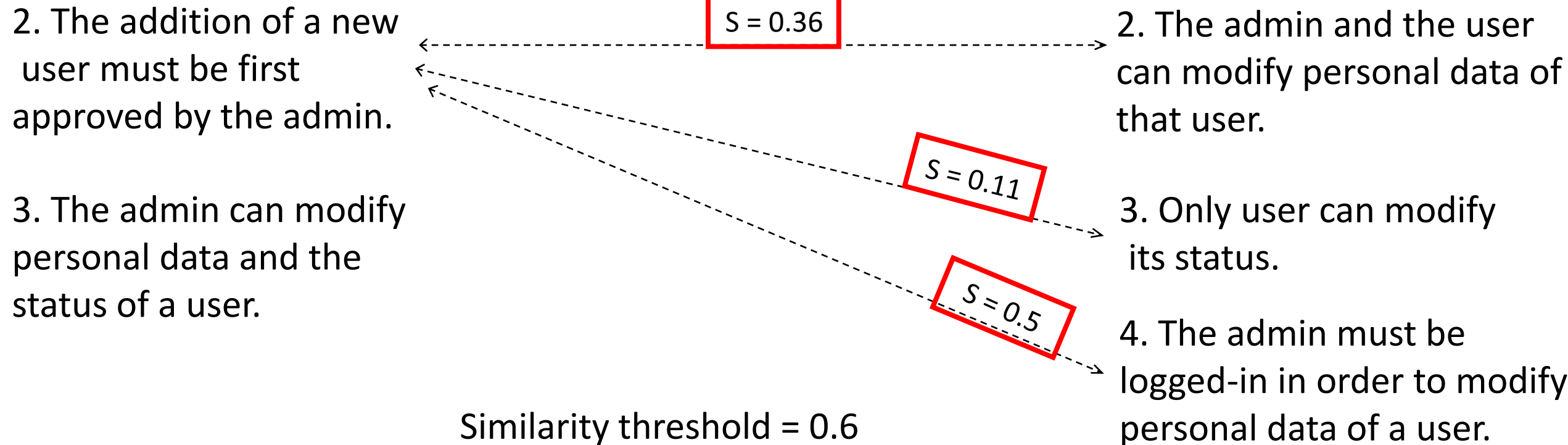
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← Unchanged sentences →



1. Identify relevant change patterns – sentence level

The sentences in oldReq:

Similarity Score (S):

The sentences in newReq:

1. A user can add new users to the group.

$S = 1$

Unchanged sentences

1. A user can add new users to the group.

2. The addition of a new user must be first approved by the admin.

$S = 0.36$

2. The admin and the user can modify personal data of that user.

3. The admin can modify personal data and the status of a user.

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The sentences in oldReq:

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1. A user can add new users to the group.

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Unchanged sentences

1. A user can add new users to the group.

2. The addition of a new user must be first approved by the admin.

$S = 0.36$

$S = 0.86$

$S = 0.11$

3. The admin can modify personal data and the status of a user.

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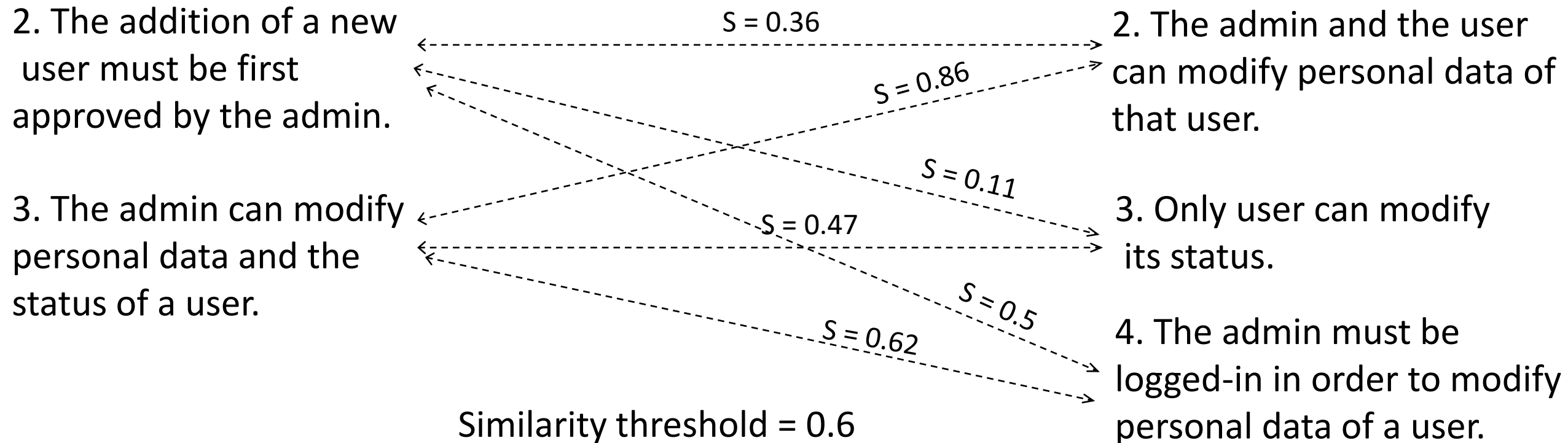
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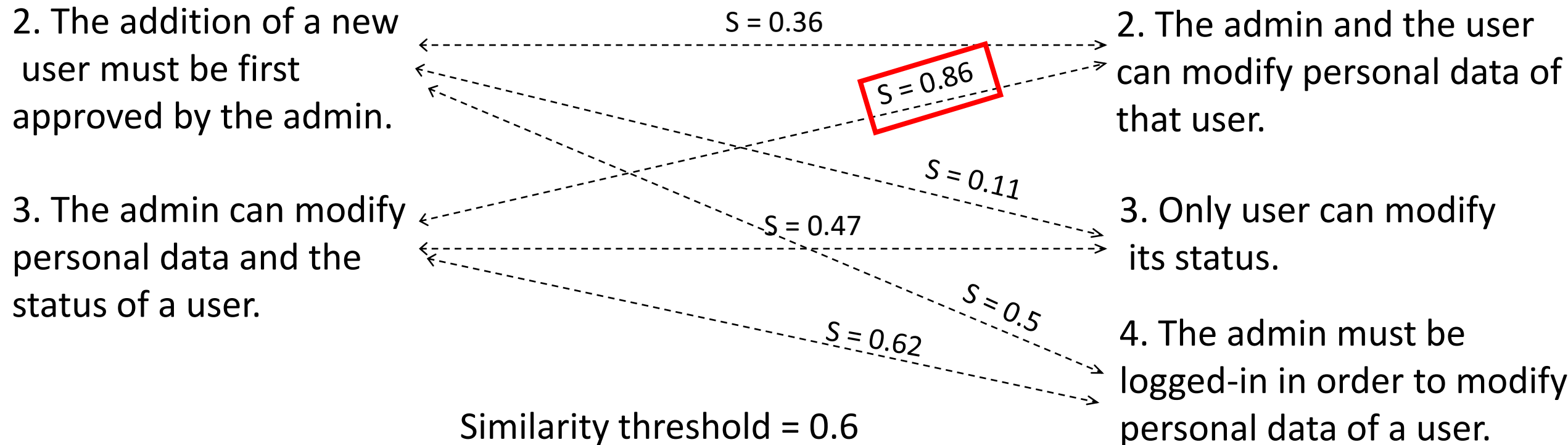
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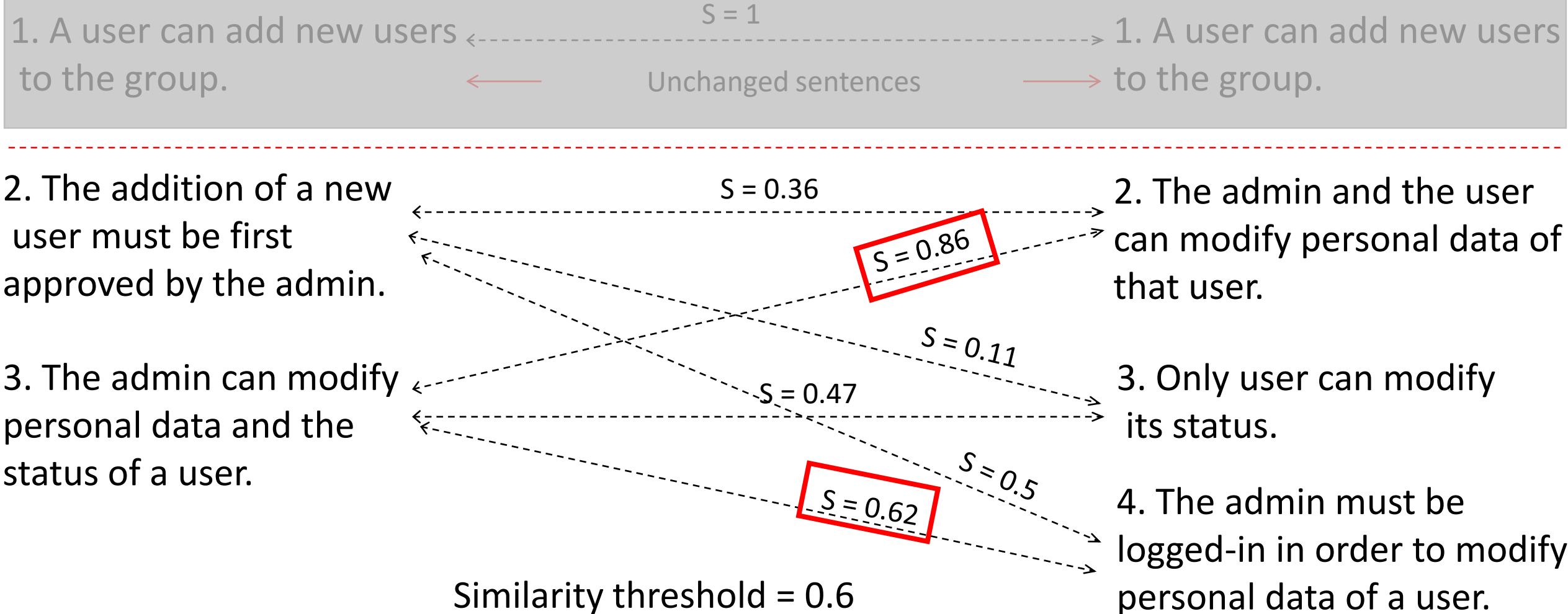


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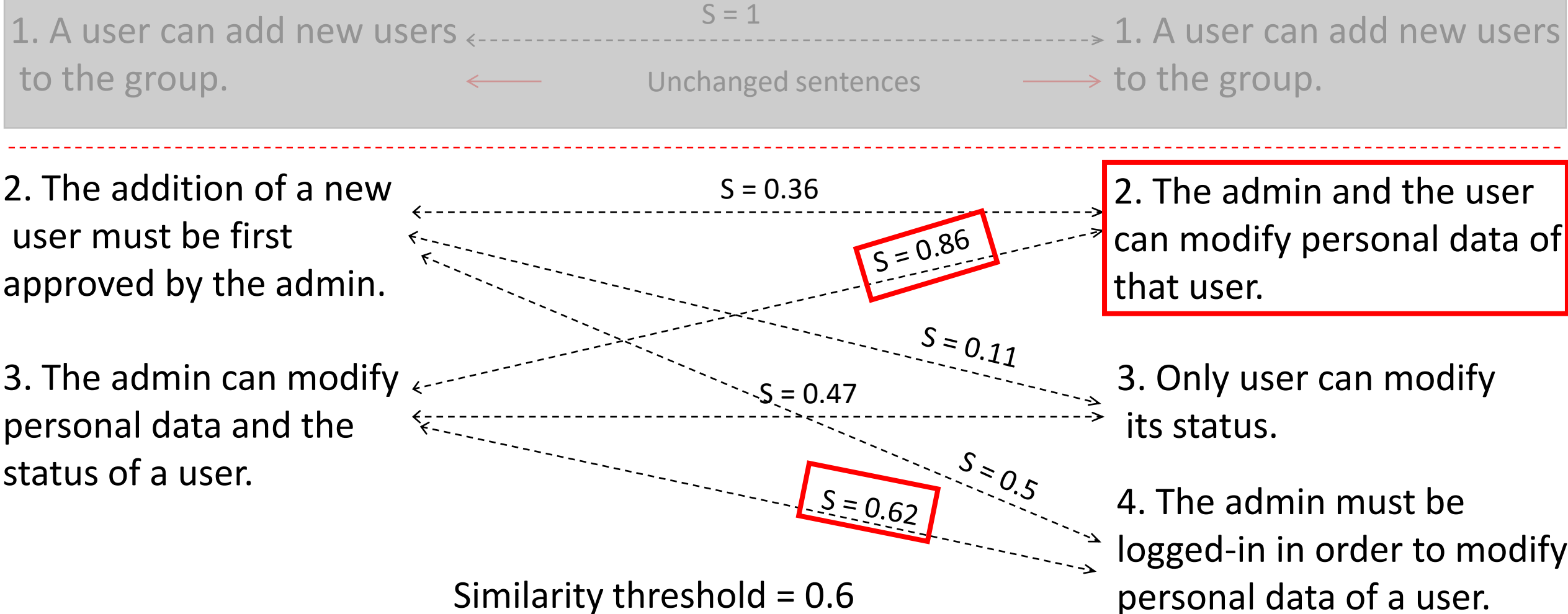


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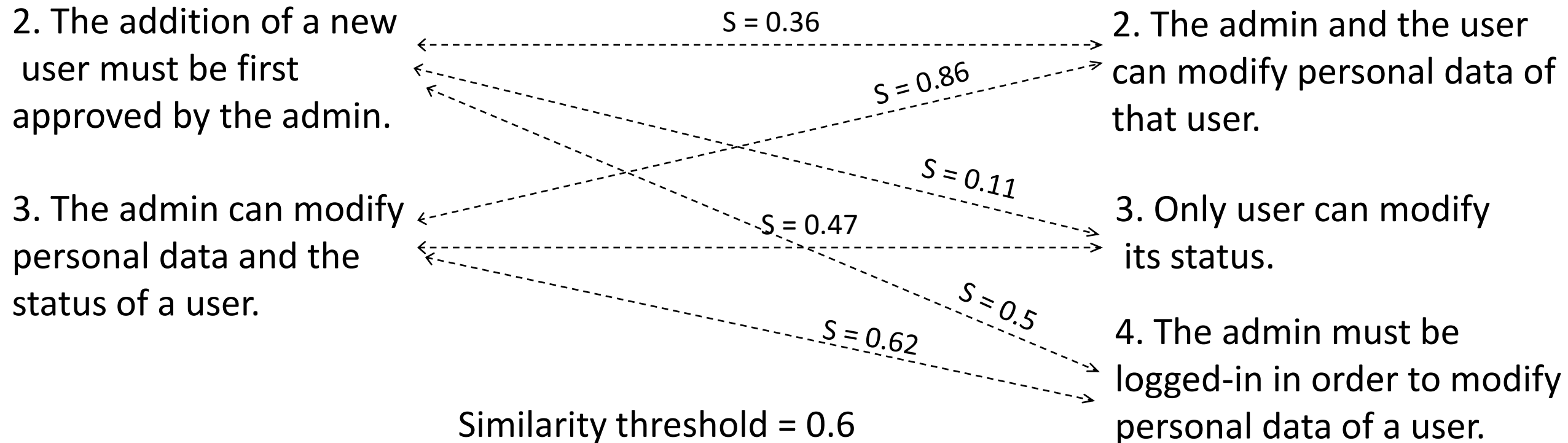
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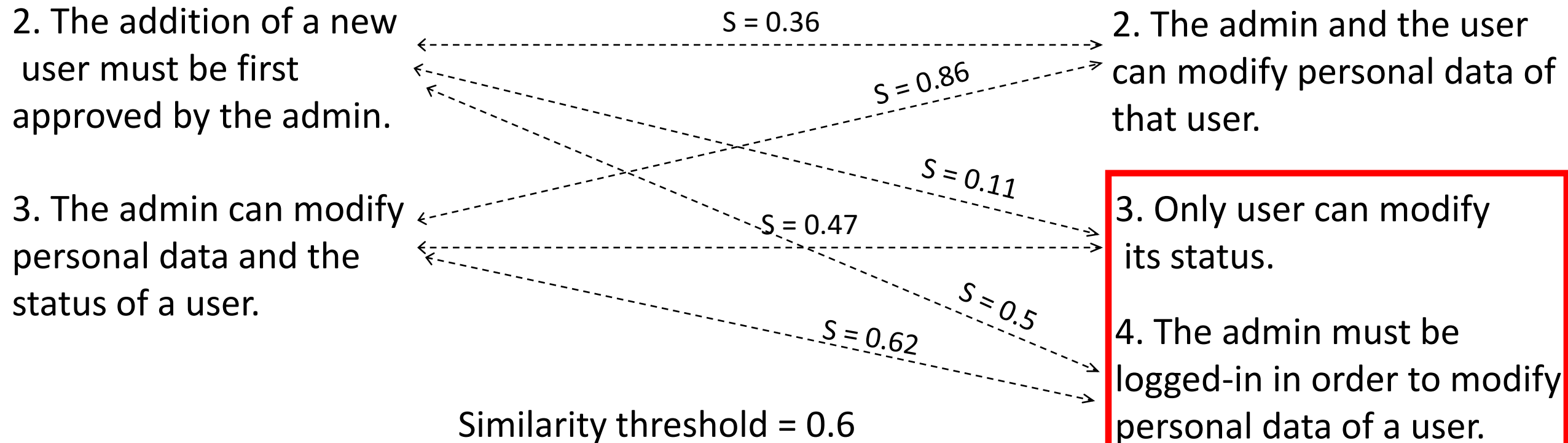
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← Unchanged sentences →



1. Identify relevant change patterns – word level

??ID	TEXT	WORD	CLASS	DEPENDENCY	GRAMMATICAL
?	?	?	?	NUMBER	FUNCTION
1	The	DET	2	det	
2	admin	NOUN	4	subj	
3	can	VERB	4	aux	
4	modify	VERB	0	ROOT	
5	personal	ADJ	6	amod	
6	data	NOUN	4	dobj	
7	and	CONJ	6	cc	
8	the	DET	9	det	
9	status	NOUN	6	conj	
10	of	ADP	9	prep	
11	a	DET	12	det	
12	user	NOUN	10	pobj	
13	.	PUNCT	0	punct	

1. Identify relevant change patterns

1.3 Identify change types using an adapted TextDiff algorithm

The admin `<add>and</add>`

`<add>the</add>`

`<add>user</add>`

can modify personal data

`and`

`the`

`status`

of `<add>that</add>`

`a` user.

2. Generate guidance

2.1 Identify static and dynamic parts of a suggestion

The admin and the user can modify personal data ~~and the status~~ of that a user.

2. Generate guidance

2.1 Identify static and dynamic parts of a suggestion

The admin and the user can modify personal data ~~and the status~~ of that a user.

2. Generate guidance

2.1 Identify static and dynamic parts of a suggestion

The admin and the user can modify personal data ~~and the status~~ of that a user.

An object is deleted => **Delete steps or their parts which verify that**

2. Generate guidance

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?	?	?	?	NUMBER	FUNCTION
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3	can	VERB	?	?	aux
4	modify	VERB	?	?	ROOT
5	personal	ADJ	?	?	mod
6	data	NOUN	?	?	obj
7	and	CONJ	?	?	c
8	the	DET	?	?	det
9	Status	NOUN	?	?	conj
10	of	ADP	?	?	prep
11	a	DET	?	?	det
12	User	NOUN	?	?	obj
13	.	PUNCT	?	?	punct

2. Generate guidance

2.1 Identify static and dynamic parts of a suggestion

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6	data	NOUN	?	?	obj
7	and	CONJ	?	?	cc
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9	status	NOUN	?	?	conj
10	of	ADP	?	?	prep
11	a	DET	?	?	det
12	user	NOUN	?	?	obj
13	.	PUNCT	?	?	punct

=> the admin can modify the status of a user.

2. Generate guidance

2.1 Identify static and dynamic parts of a suggestion

The admin and the user can modify personal data ~~and the status~~ of that a user.

An object is deleted => Delete steps or their parts which verify that

=> the admin can modify the status of a user.

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6	data	NOUN	?	?	obj
7	and	CONJ	?	?	c
8	the	DET	?	?	det
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11	a	DET	?	?	det
12	user	NOUN	?	?	obj
13	.	PUNCT	?	?	punct

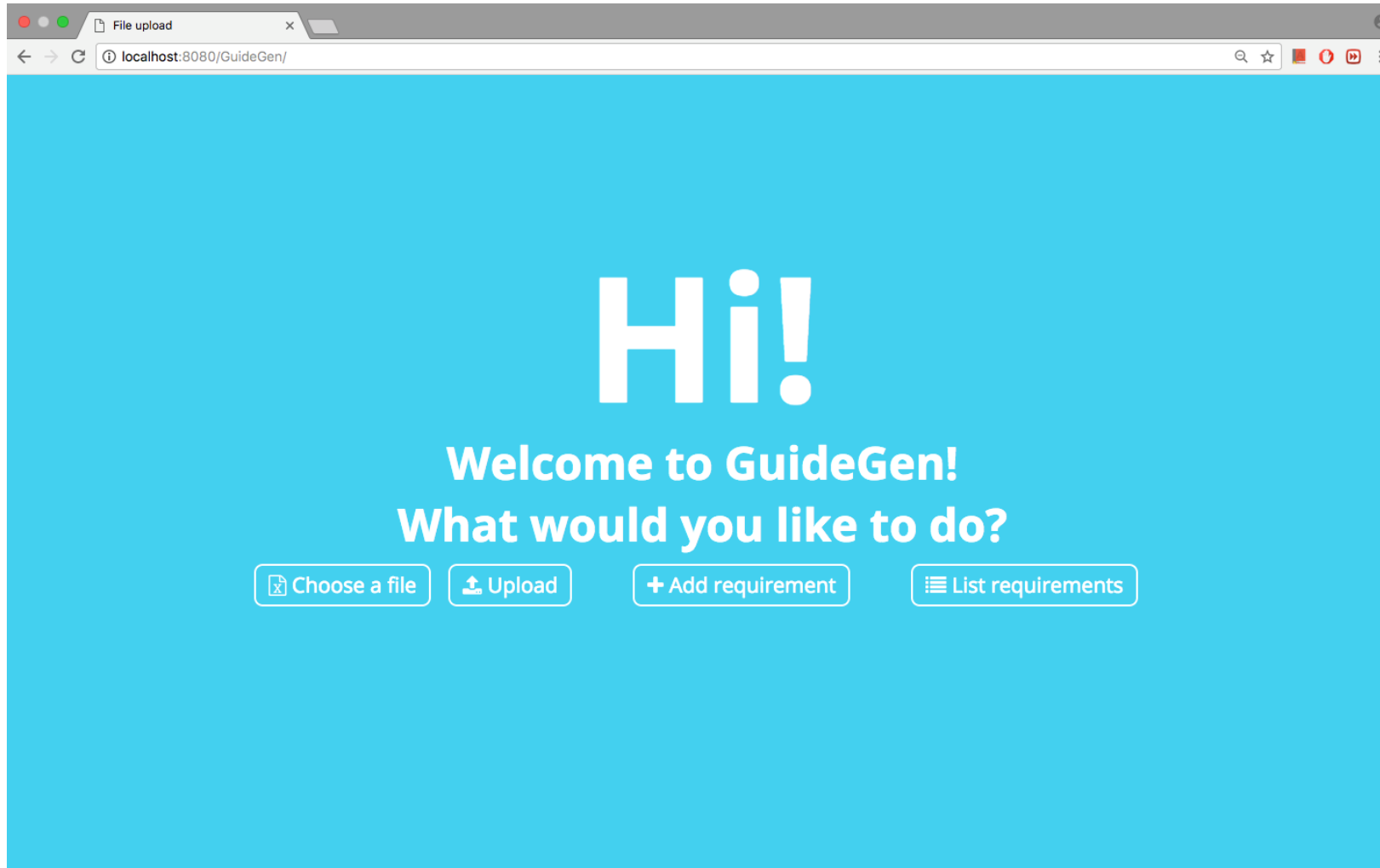
3. Notify subscribed parties

1. E-mail:

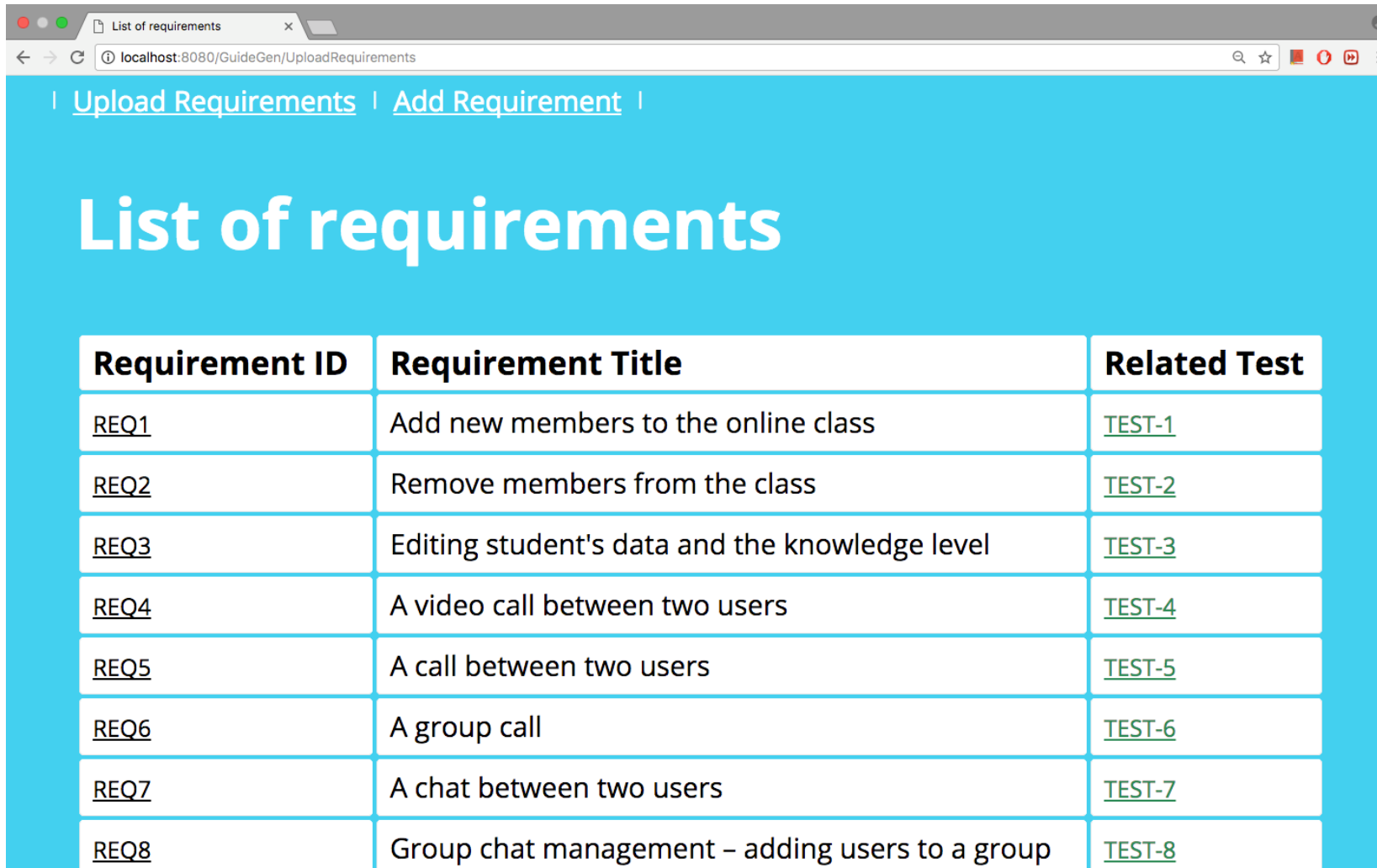
- Affected test id and description
- Relevant guidance
- Summarized changes

2. Warnings

Tool prototype



Tool prototype

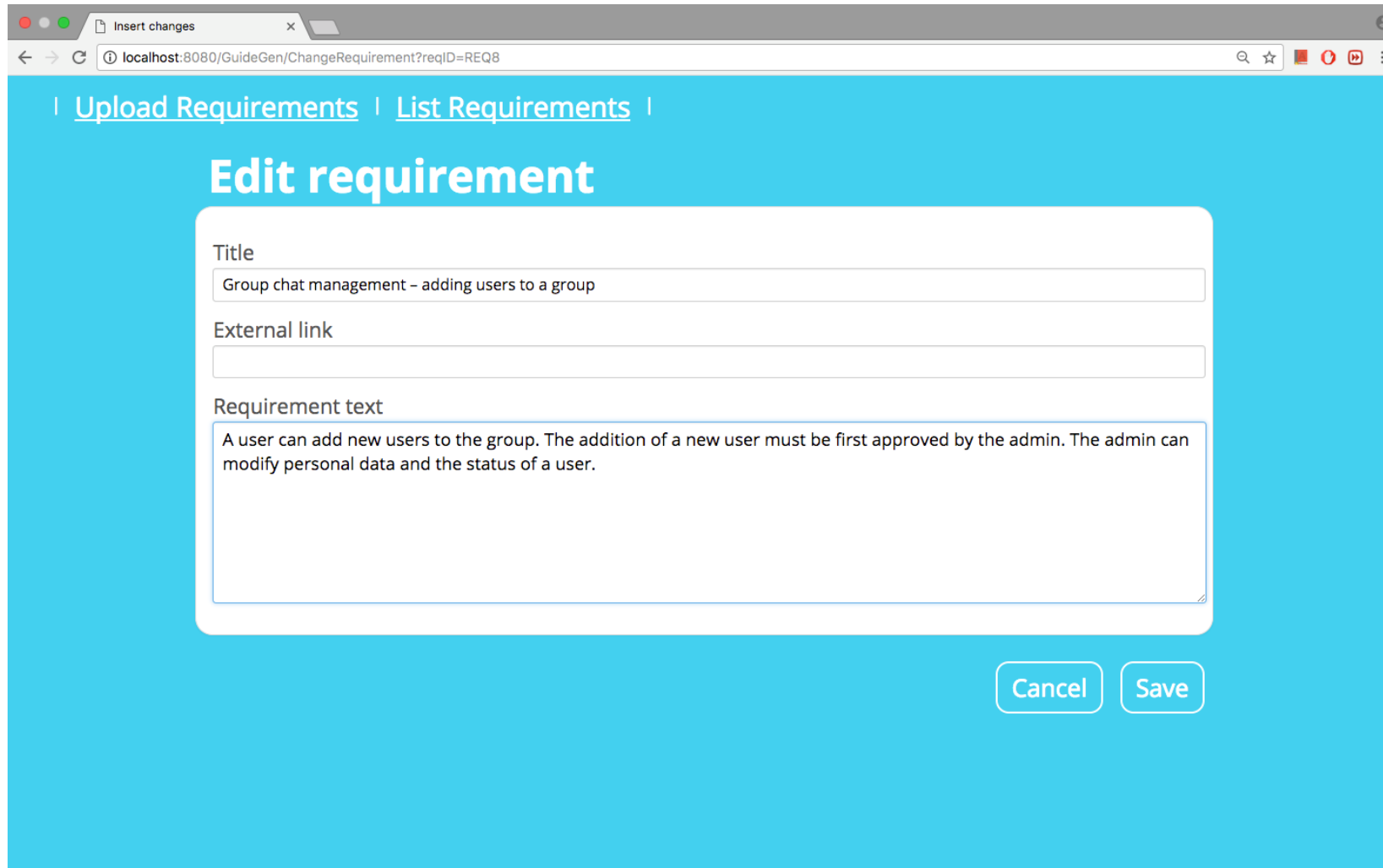


Upload Requirements | Add Requirement |

List of requirements

Requirement ID	Requirement Title	Related Test
REQ1	Add new members to the online class	TEST-1
REQ2	Remove members from the class	TEST-2
REQ3	Editing student's data and the knowledge level	TEST-3
REQ4	A video call between two users	TEST-4
REQ5	A call between two users	TEST-5
REQ6	A group call	TEST-6
REQ7	A chat between two users	TEST-7
REQ8	Group chat management – adding users to a group	TEST-8

Tool prototype



The screenshot shows a web browser window with a single tab titled 'Insert changes'. The address bar displays 'localhost:8080/GuideGen/ChangeRequirement?reqID=REQ8'. The browser's top navigation bar features two links: 'Upload Requirements' and 'List Requirements', both underlined. The main content area has a light blue background and a white rounded rectangle in the center. The title 'Edit requirement' is positioned at the top of this rectangle. Below the title are three input fields: 'Title' (containing 'Group chat management – adding users to a group'), 'External link' (empty), and 'Requirement text' (containing a paragraph about user approval). At the bottom right of the white rectangle are two buttons: 'Cancel' and 'Save'.

Insert changes

localhost:8080/GuideGen/ChangeRequirement?reqID=REQ8

[Upload Requirements](#) | [List Requirements](#)

Edit requirement

Title

Group chat management – adding users to a group

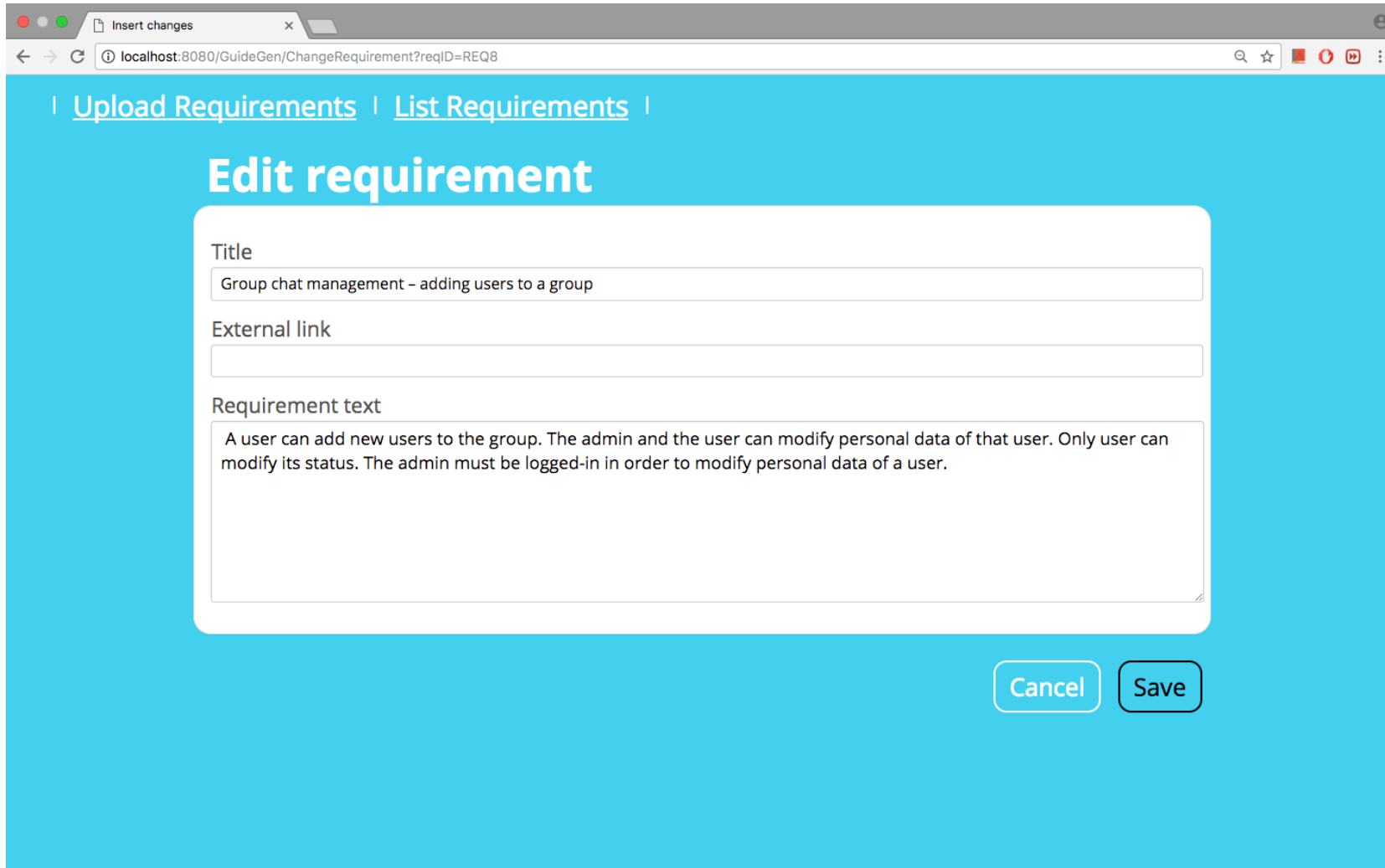
External link

Requirement text

A user can add new users to the group. The addition of a new user must be first approved by the admin. The admin can modify personal data and the status of a user.

Cancel Save

Tool prototype



The screenshot shows a web browser window with a single tab titled 'Insert changes'. The address bar displays 'localhost:8080/GuideGen/ChangeRequirement?reqID=REQ8'. The browser's toolbar includes back, forward, and refresh buttons, along with search, star, and extension icons. The page has a light blue header with navigation links: '| [Upload Requirements](#) | [List Requirements](#) |'. The main content area is titled 'Edit requirement' in large white text. Below this, a white form contains three sections: 'Title' with the text 'Group chat management - adding users to a group', 'External link' with an empty field, and 'Requirement text' with a text area containing the paragraph: 'A user can add new users to the group. The admin and the user can modify personal data of that user. Only user can modify its status. The admin must be logged-in in order to modify personal data of a user.' At the bottom right of the form are two buttons: 'Cancel' and 'Save'.

Insert changes

localhost:8080/GuideGen/ChangeRequirement?reqID=REQ8

| [Upload Requirements](#) | [List Requirements](#) |

Edit requirement

Title

Group chat management - adding users to a group

External link

Requirement text

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Cancel Save

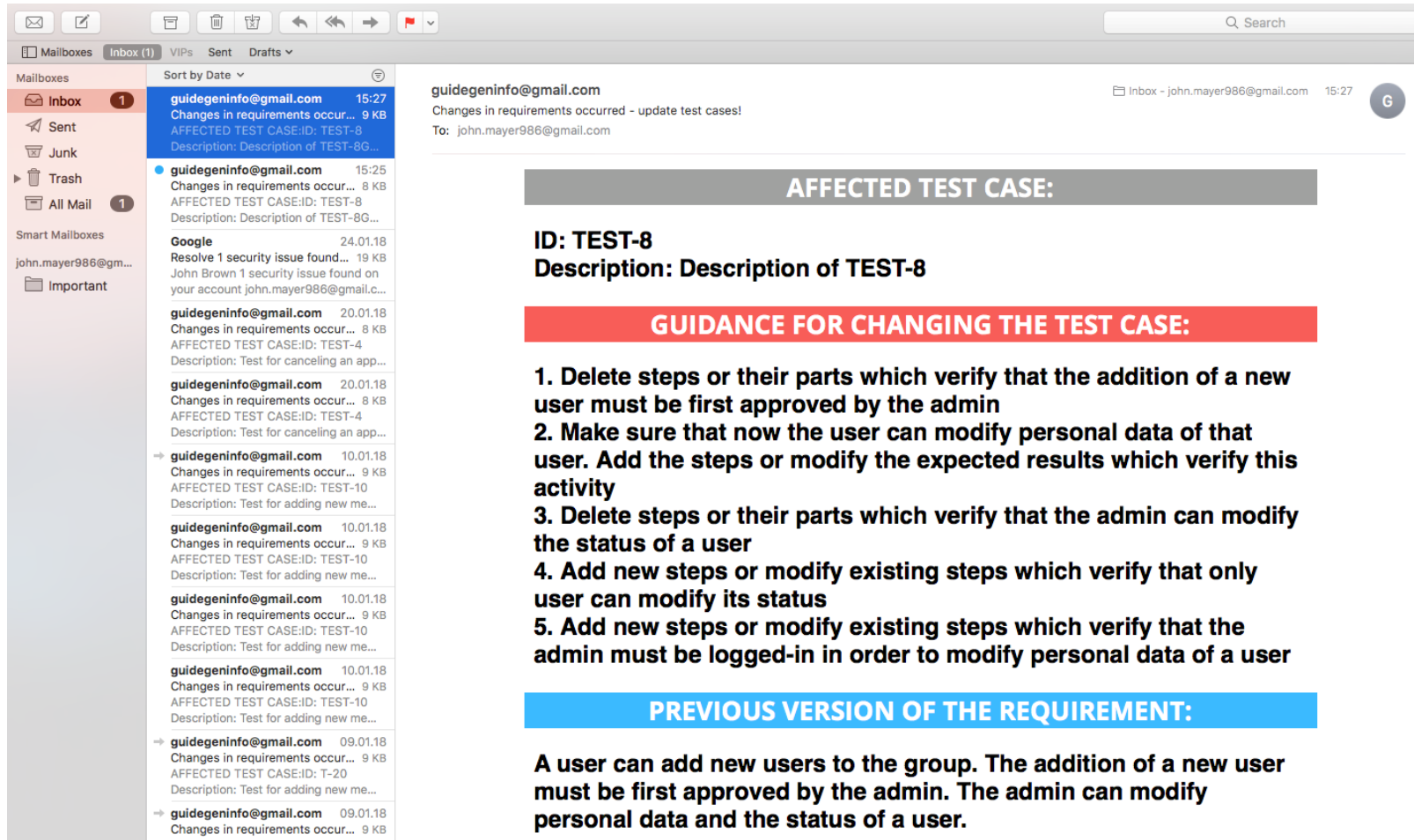
Tool prototype

The screenshot shows a web browser window with the address bar displaying 'localhost:8080/GuideGen/ChangeProcessor'. The page has a light blue background and a white title bar. The main heading is 'Change the acceptance test:'. Below this, there is a table with five rows, each containing a step description and an 'Ignore' checkbox. At the bottom right, there are two buttons: 'Cancel' and 'Confirm and email'.

Change the acceptance test:	
1. Delete steps or their parts which verify that the addition of a new user must be first approved by the admin.	<input type="checkbox"/> Ignore
2. Make sure that now the user can modify personal data of that user. Add the steps or modify the expected results which verify this activity.	<input type="checkbox"/> Ignore
3. Delete steps or their parts which verify that the admin can modify the status of a user.	<input type="checkbox"/> Ignore
4. Add new steps or modify existing steps which verify that only user can modify its status.	<input type="checkbox"/> Ignore
5. Add new steps or modify existing steps which verify that the admin must be logged-in in order to modify personal data of a user.	<input type="checkbox"/> Ignore

[Cancel](#) [Confirm and email](#)

Tool prototype



The screenshot shows a Gmail interface. On the left, the 'Mailboxes' sidebar lists 'Inbox (1)', 'Sent', 'Junk', 'Trash', and 'All Mail (1)'. Below these are 'Smart Mailboxes' for 'john.mayer986@gmail.com' and 'Important'. The main email list is sorted by date and shows several emails from 'guidegeninfo@gmail.com' with subject lines like 'Changes in requirements occur...' and 'AFFECTED TEST CASE:ID: TEST-8'. The selected email is open on the right, showing the sender 'guidegeninfo@gmail.com', the subject 'Changes in requirements occurred - update test cases!', and the recipient 'john.mayer986@gmail.com'. The email body contains three sections: 'AFFECTED TEST CASE:', 'GUIDANCE FOR CHANGING THE TEST CASE:', and 'PREVIOUS VERSION OF THE REQUIREMENT:'.

AFFECTED TEST CASE:

ID: TEST-8
Description: Description of TEST-8

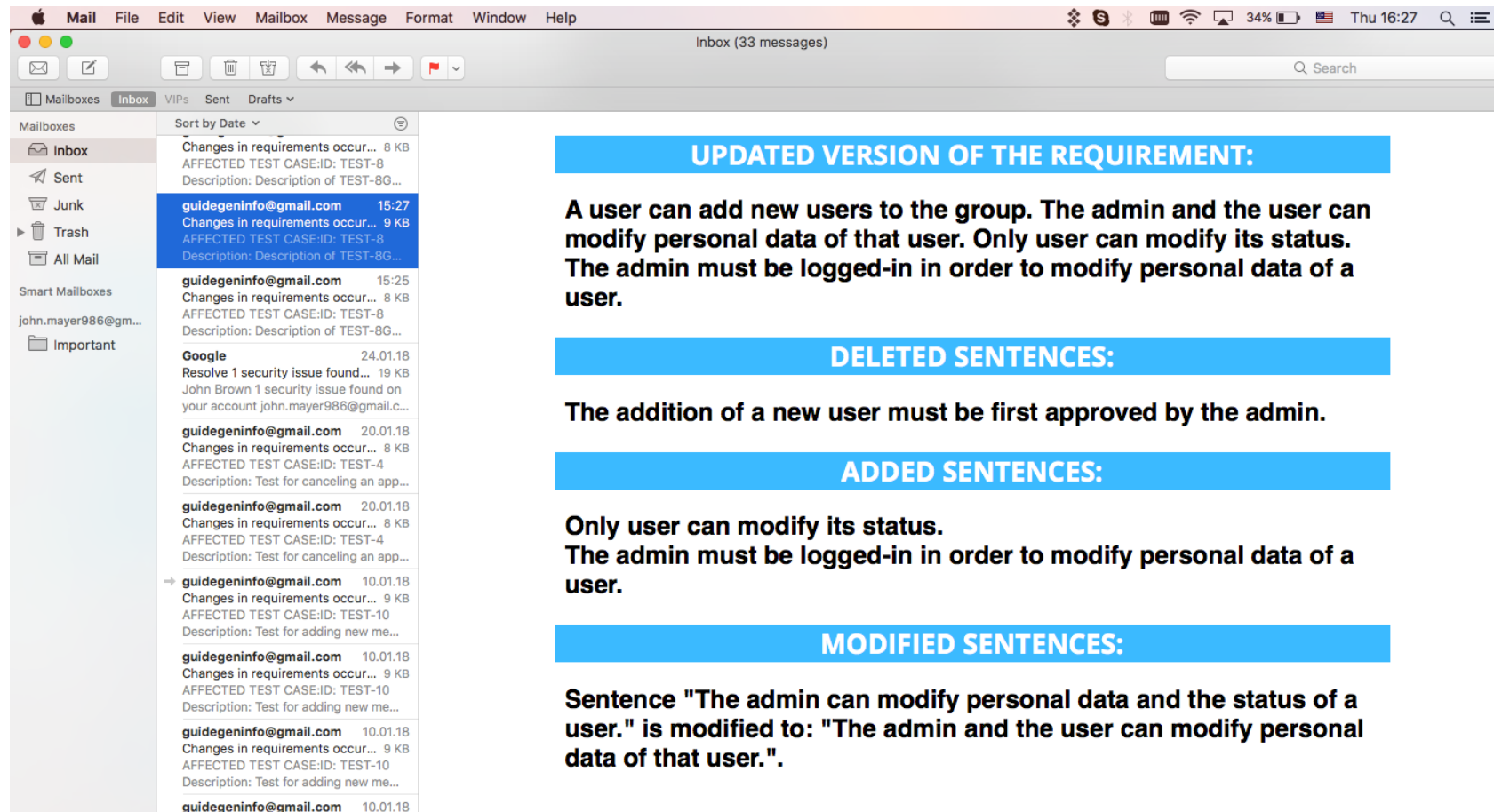
GUIDANCE FOR CHANGING THE TEST CASE:

1. Delete steps or their parts which verify that the addition of a new user must be first approved by the admin
2. Make sure that now the user can modify personal data of that user. Add the steps or modify the expected results which verify this activity
3. Delete steps or their parts which verify that the admin can modify the status of a user
4. Add new steps or modify existing steps which verify that only user can modify its status
5. Add new steps or modify existing steps which verify that the admin must be logged-in in order to modify personal data of a user

PREVIOUS VERSION OF THE REQUIREMENT:

A user can add new users to the group. The addition of a new user must be first approved by the admin. The admin can modify personal data and the status of a user.

Tool prototype



UPDATED VERSION OF THE REQUIREMENT:

A user can add new users to the group. The admin and the user can modify personal data of that user. Only user can modify its status. The admin must be logged-in in order to modify personal data of a user.

DELETED SENTENCES:

The addition of a new user must be first approved by the admin.

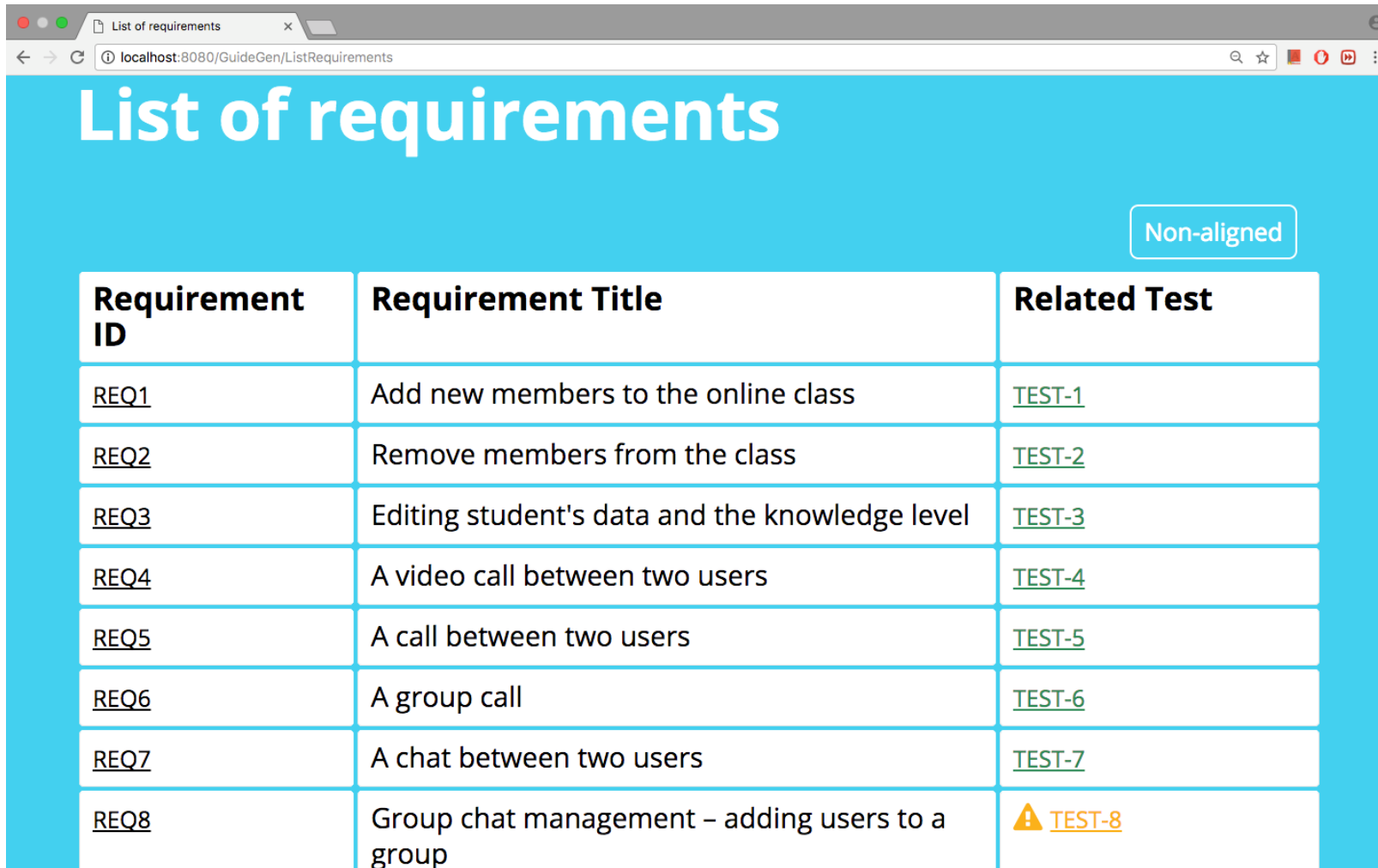
ADDED SENTENCES:


**Only user can modify its status.
The admin must be logged-in in order to modify personal data of a user.**

MODIFIED SENTENCES:

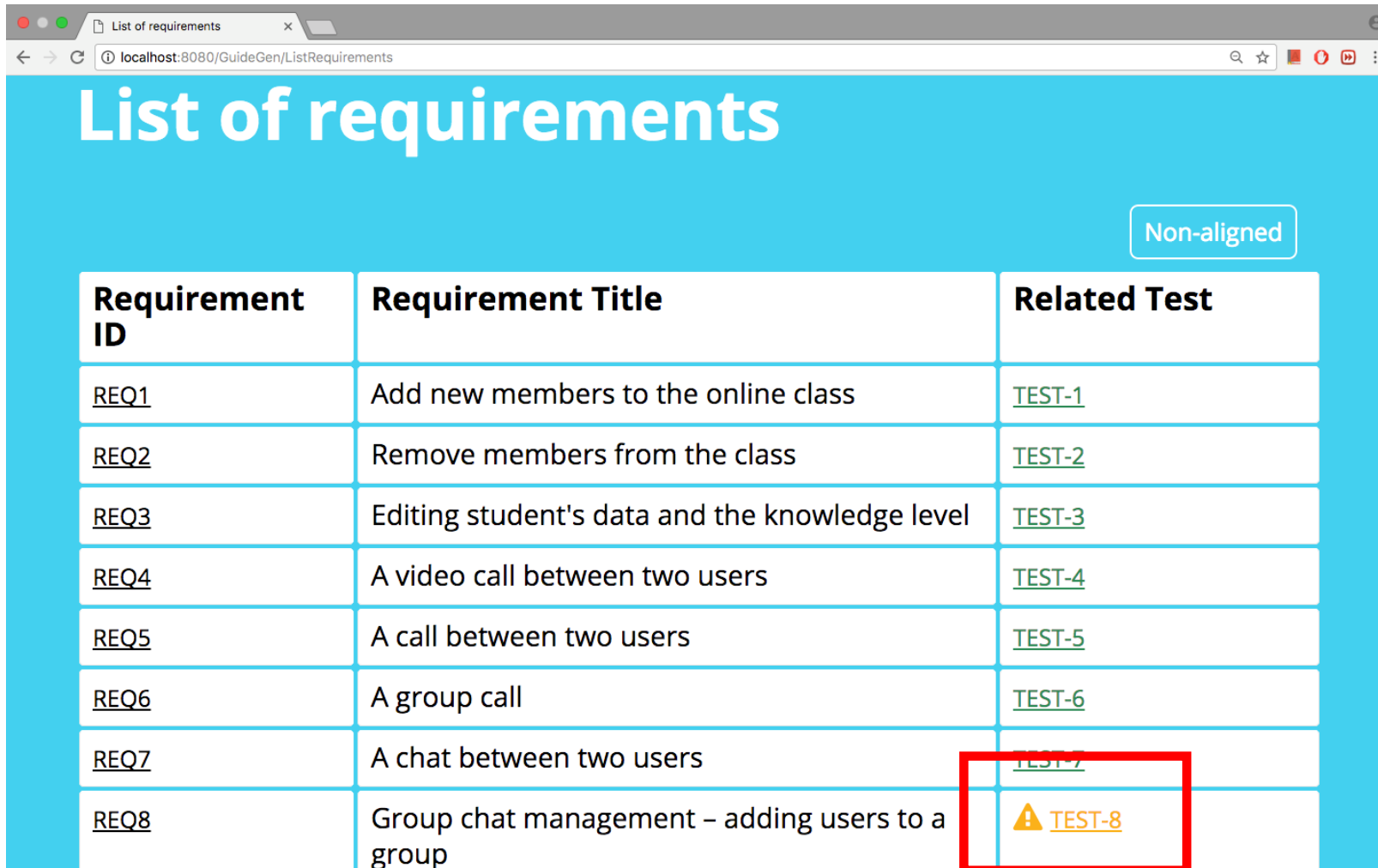
Sentence "The admin can modify personal data and the status of a user." is modified to: "The admin and the user can modify personal data of that user.".

Tool prototype




Requirement ID	Requirement Title	Related Test
REQ1	Add new members to the online class	TEST-1
REQ2	Remove members from the class	TEST-2
REQ3	Editing student's data and the knowledge level	TEST-3
REQ4	A video call between two users	TEST-4
REQ5	A call between two users	TEST-5
REQ6	A group call	TEST-6
REQ7	A chat between two users	TEST-7
REQ8	Group chat management – adding users to a group	 TEST-8

Tool prototype



List of requirements

Non-aligned

Requirement ID	Requirement Title	Related Test
REQ1	Add new members to the online class	TEST-1
REQ2	Remove members from the class	TEST-2
REQ3	Editing student's data and the knowledge level	TEST-3
REQ4	A video call between two users	TEST-4
REQ5	A call between two users	TEST-5
REQ6	A group call	TEST-6
REQ7	A chat between two users	TEST-7
REQ8	Group chat management – adding users to a group	 TEST-8

Tool prototype

Insert changes x

localhost:8080/GuideGen/UpdateTestCase?testId=TEST-8

[Upload Requirements](#) | [List Requirements](#) |

Edit test case

Description

Description of TEST-8

Steps and Expected Results

Steps:	Expected results:
Log-in as user	Login successful
2. Open the page with the list of groups	The page is opened and the list with users' groups is visible
3. Click on the button "Manage group" next	The group members are listed and there is a button "Add users"

Instructions:

1. Delete steps or their parts which verify that the addition of a new user must be first approved by the admin
2. Make sure that now the user can modify personal data of that user. Add the steps or modify the expected results which verify this activity
3. Delete steps or their parts which verify that the admin can modify the status of a user
4. Add new steps or modify existing steps which verify that only user can modify its status
5. Add new steps or modify existing steps which verify that the admin must be logged-in in order to modify personal data of a user

[Cancel](#) [Save](#)

Evaluation – study design

Dataset/Company	Type of requirements	Number of generated suggestions	Number of experts
DS1/C1	User story	28	2
DS2/C2	User story	37	2
DS3/C3	Unstructured text	197	3

Evaluation - results

Evaluation - results

Correct actions

Evaluation - results

Correct actions

Grammatically correct

Evaluation - results

Correct actions

Grammatically correct

Complete

Evaluation - results

Correct actions

Grammatically correct

Complete

Understandable

Evaluation - results

Correct actions

Grammatically correct

Complete

Understandable

Self-explanatory

Evaluation - results

Correct actions

Grammatically correct

Complete

Understandable

Self-explanatory

Redundant/Unnecessary

Evaluation - results

Correct actions

Grammatically correct

Complete

Understandable

Self-explanatory

Redundant/Unnecessary

Missing

Evaluation - results

Correct actions	> 80% (user stories), ±67% (unstructured)
Grammatically correct	
Complete	
Understandable	
Self-explanatory	
Redundant/Unnecessary	
Missing	

Evaluation - results

Correct actions	> 80% (user stories), ±67% (unstructured)
Grammatically correct	> 80% (DS1, DS3), 67.5% (DS2)
Complete	
Understandable	
Self-explanatory	
Redundant/Unnecessary	
Missing	

Evaluation - results

Correct actions	> 80% (user stories), ±67% (unstructured)
Grammatically correct	> 80% (DS1, DS3), 67.5% (DS2)
Complete	Almost all (> 95%)
Understandable	
Self-explanatory	
Redundant/Unnecessary	
Missing	

Evaluation - results

Correct actions	> 80% (user stories), ±67% (unstructured)
Grammatically correct	> 80% (DS1, DS3), 67.5% (DS2)
Complete	Almost all (> 95%)
Understandable	Almost all (> 95%)
Self-explanatory	
Redundant/Unnecessary	
Missing	

Evaluation - results

Correct actions	> 80% (user stories), $\pm 67\%$ (unstructured)
Grammatically correct	> 80% (DS1, DS3), 67.5% (DS2)
Complete	Almost all (> 95%)
Understandable	Almost all (> 95%)
Self-explanatory	$\pm 73\%$
Redundant/Unnecessary	
Missing	

Evaluation - results

Correct actions	> 80% (user stories), ±67% (unstructured)
Grammatically correct	> 80% (DS1, DS3), 67.5% (DS2)
Complete	Almost all (> 95%)
Understandable	Almost all (> 95%)
Self-explanatory	± 73%
Redundant/Unnecessary	< 10% (DS1, DS2), ± 30%(DS3)
Missing	

Evaluation - results

Correct actions	> 80% (user stories), ±67% (unstructured)
Grammatically correct	> 80% (DS1, DS3), 67.5% (DS2)
Complete	Almost all (> 95%)
Understandable	Almost all (> 95%)
Self-explanatory	± 73%
Redundant/Unnecessary	< 10% (DS1, DS2), ± 30%(DS3)
Missing	< 6%

Summary

Summary

Motivation

Non-aligned documents



Poor communication



=>

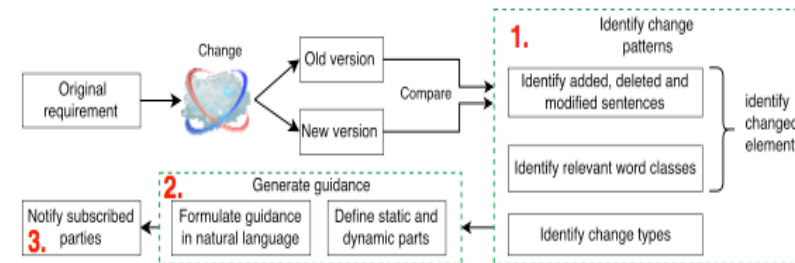


Summary

Motivation



GuideGen overview

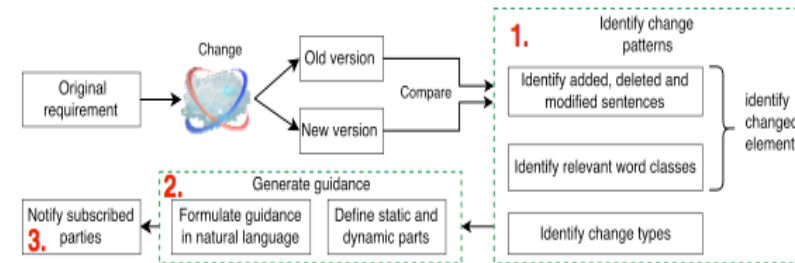


Summary

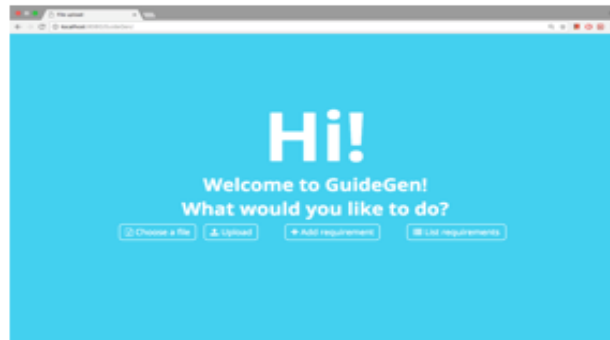
Motivation



GuideGen overview



Tool prototype

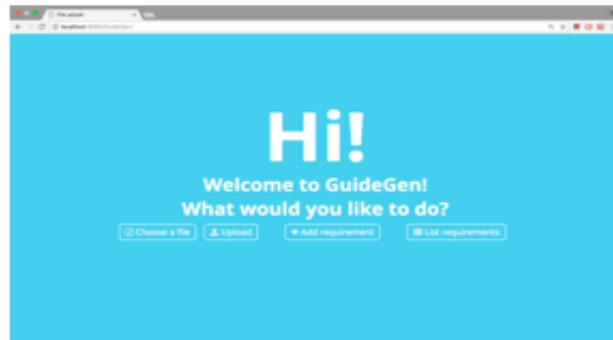


Summary

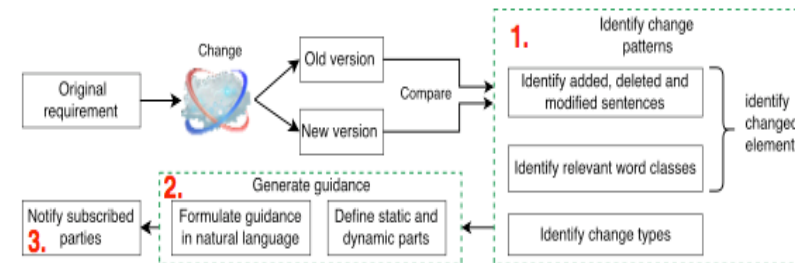
Motivation



Tool prototype



GuideGen overview



Evaluation - results

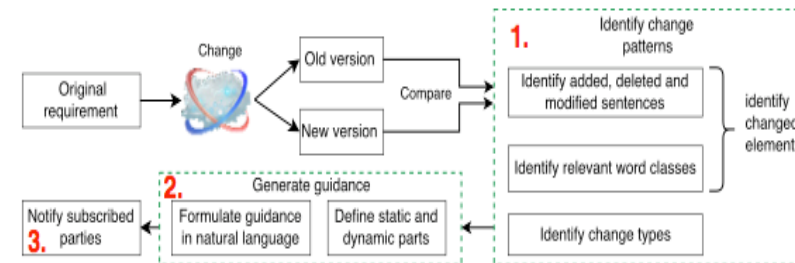
Correct actions	> 80% (user stories), ±67% (unstructured)
Grammatically correct	> 80% (DS1, DS3), 67.5% (DS2)
Complete	Almost all (> 95%)
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Missing	< 6%

Summary

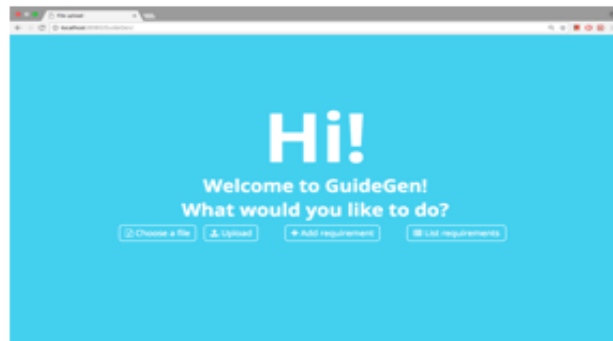
Motivation



GuideGen overview



Tool prototype



Evaluation - results

Correct actions	> 80% (user stories), ±67% (unstructured)
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Missing	< 6%

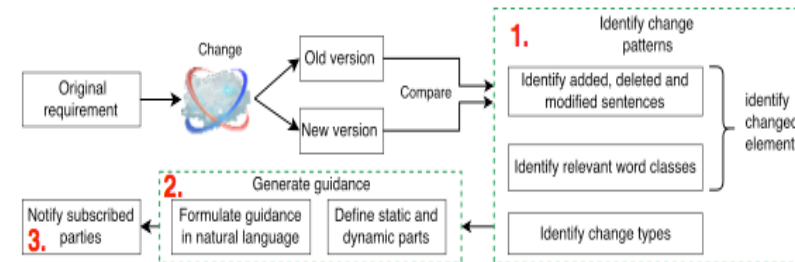
www.guidegen.org

Summary

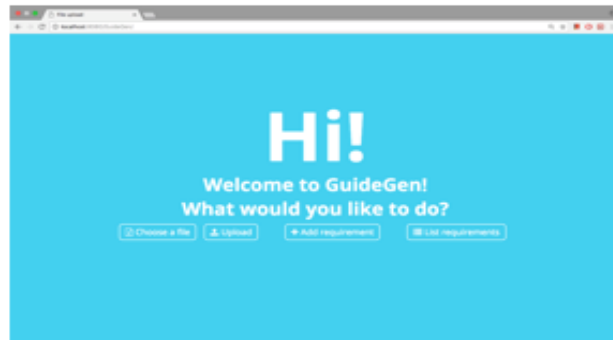
Motivation



GuideGen overview



Tool prototype



Evaluation - results

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