

ZHI-WEI LI

ENTITY-LOCATION SYSTEM AND ITS EXTENSIONS

COGNITIVE SYSTEM FOR AEC DESIGN



Real life application: design aids

Generalization: new designs, new rules

Relations: knowledge base of rules

Building block: vocabulary

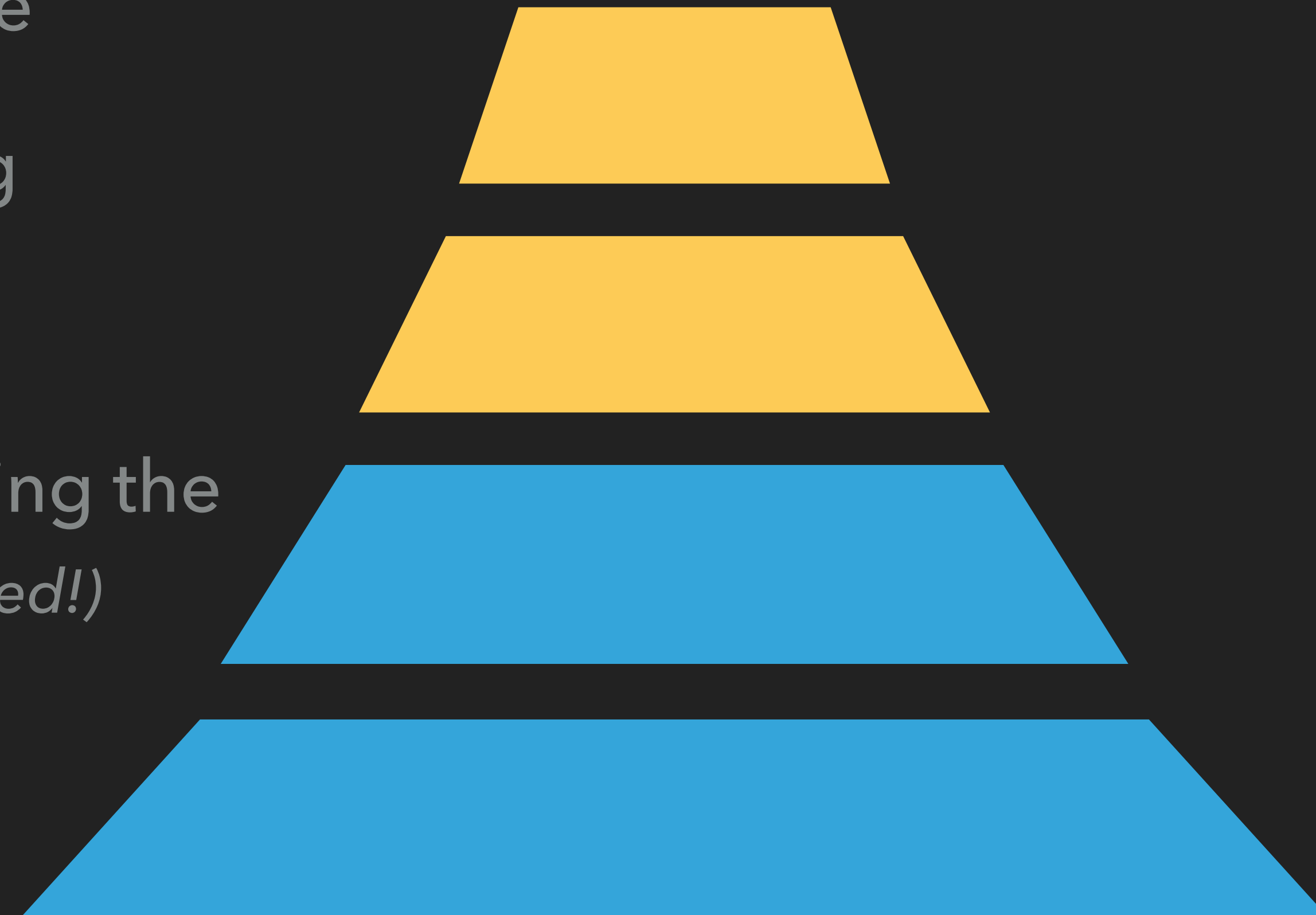
AGENDA

- ▶ Basic system
 - ▶ Front end: Interface
 - ▶ Back end: Learning
- ▶ Evaluation



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- ▶ Basic system
 - ▶ Front end: Interface
 - ▶ Back end: Learning
- ▶ Evaluation
- ▶ Extension: Generalizing the rules (*Concerns addressed!*)



Application: design aids

**Generalization: new designs,
new rules**

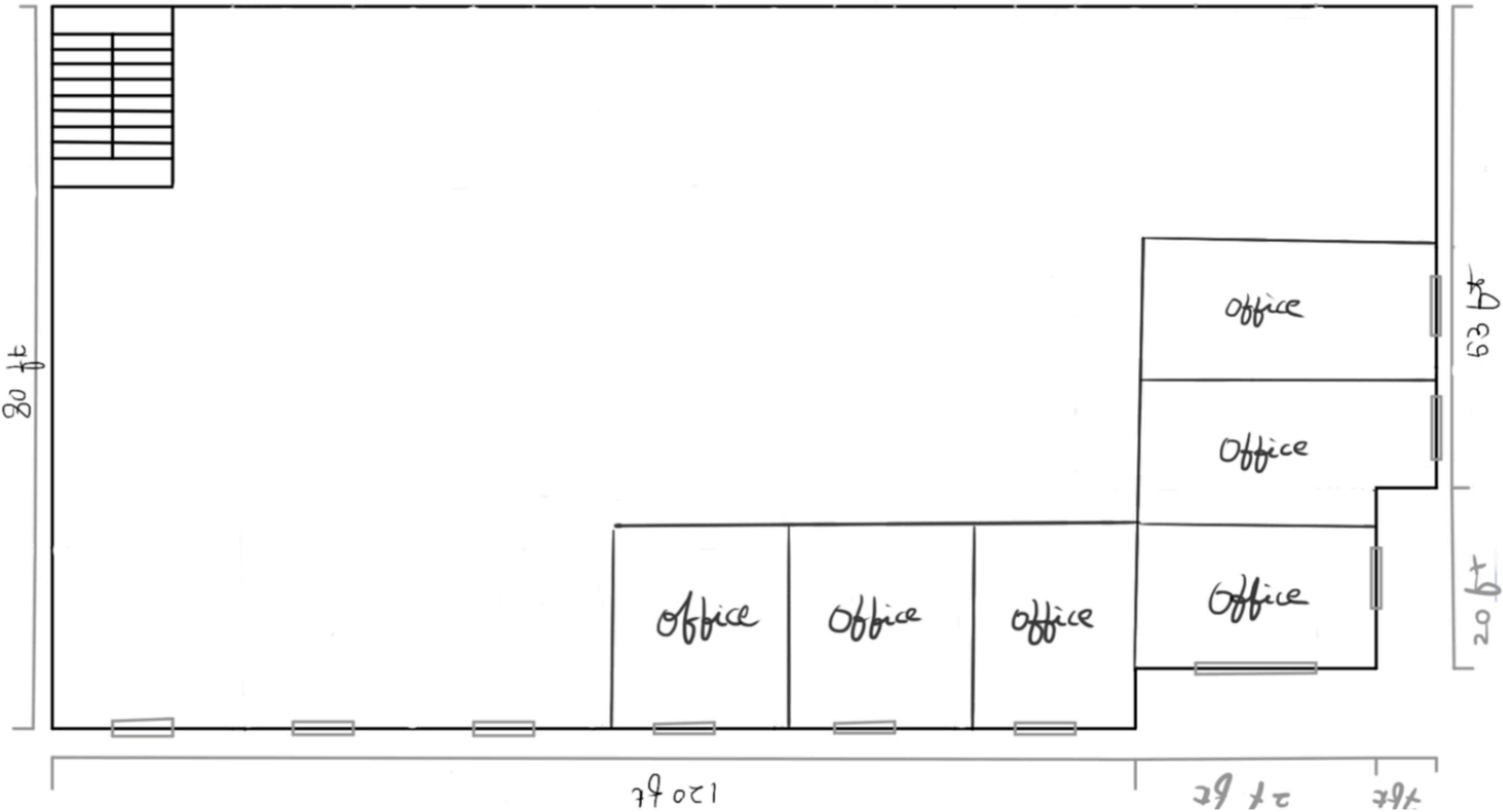
**Relations: knowledge base
of rules**

Building block: vocabulary

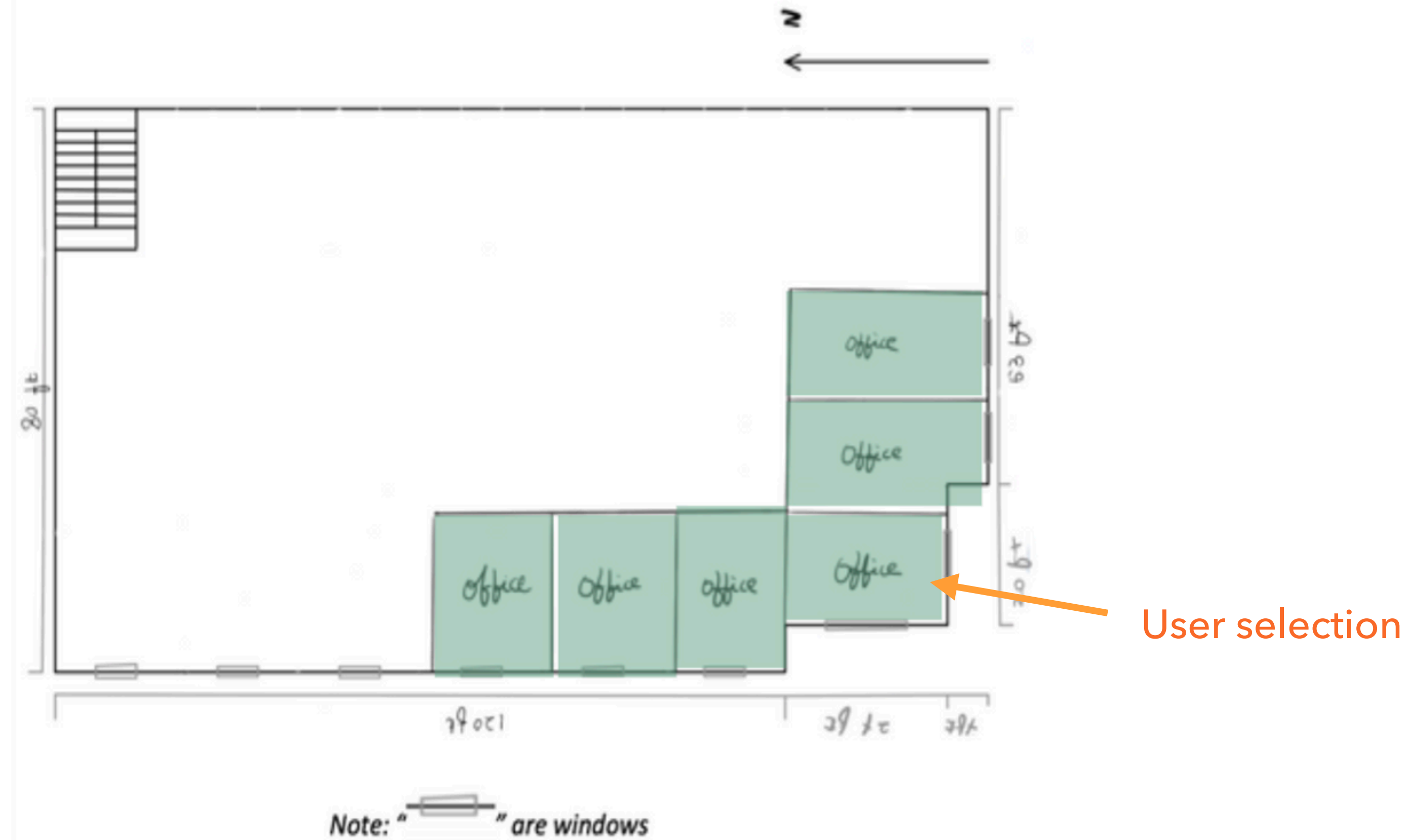
**INTERFACE:
STEP-BY-STEP**

Example rule:

“internal employee space should be placed next to the window”

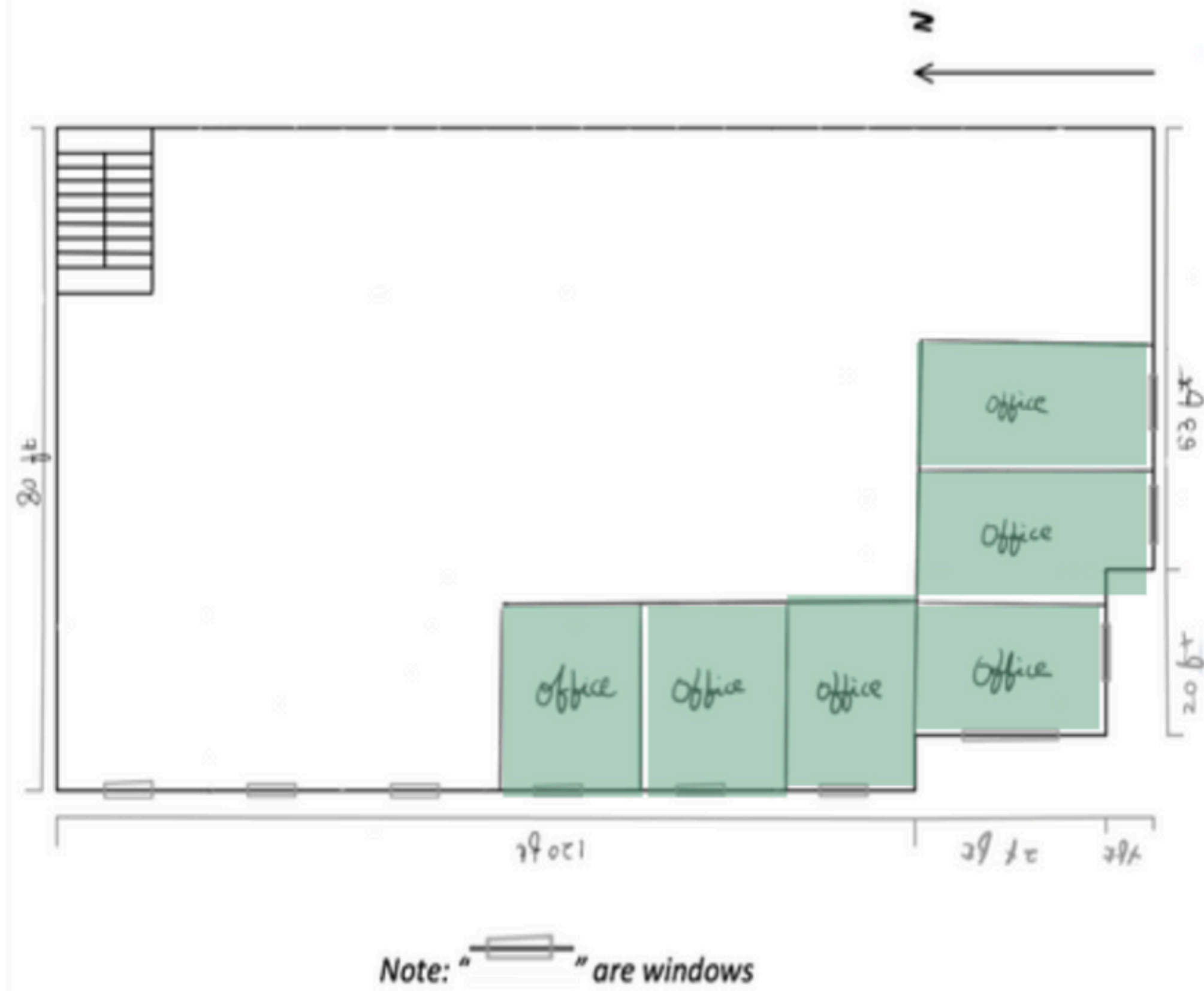


Step 1: Mark the entity on the graph



click to select the entity you are thinking of

Step 2: Name the entity



Name this entity by selecting the tags or write your own definition.

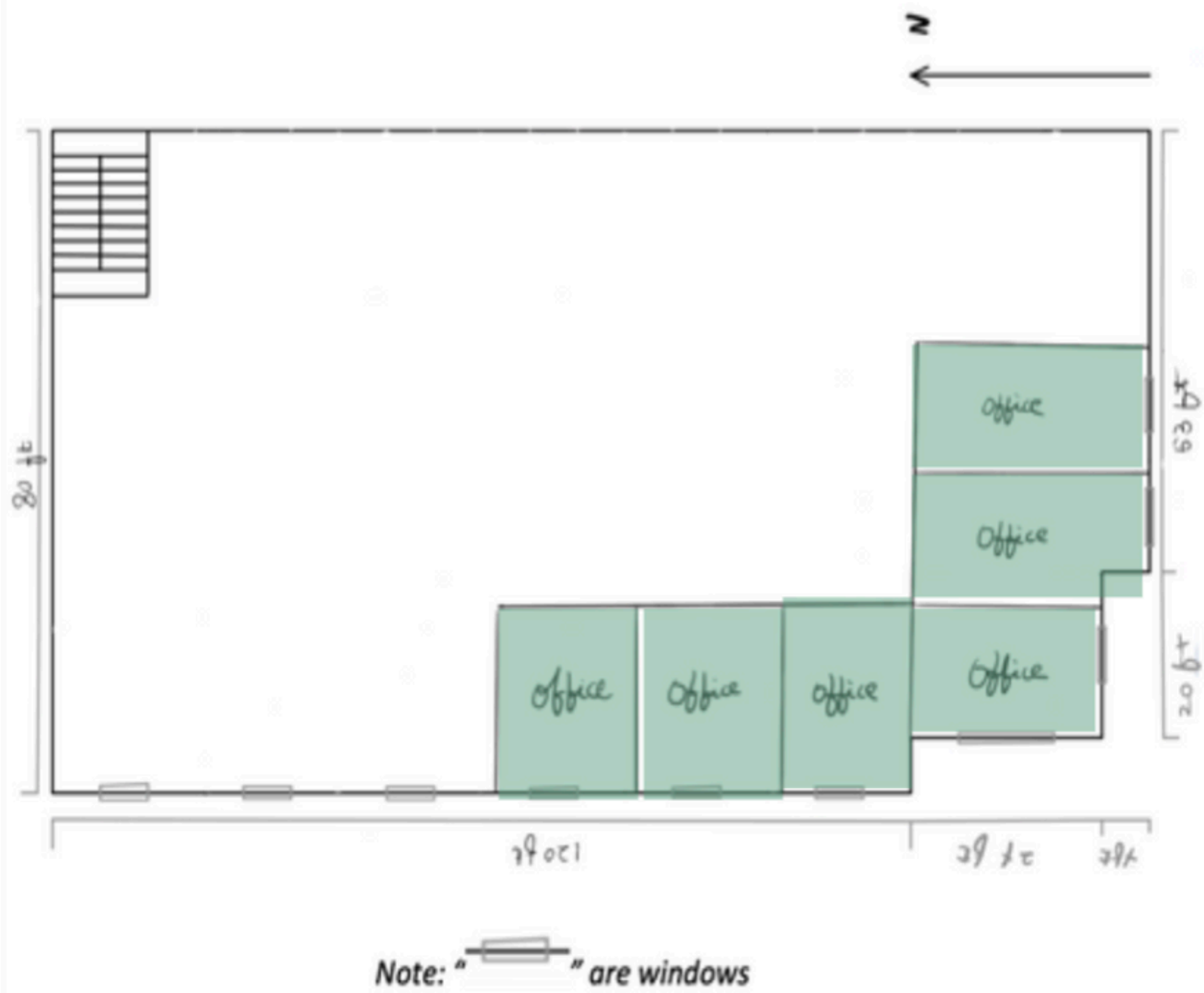
Internal employee space

User input

- office
- work area
- meeting area

System suggestions

Step 3: Choose the location descriptor



Internal employee space

should be placed **next to**

- office

work area

meeting area
- next to

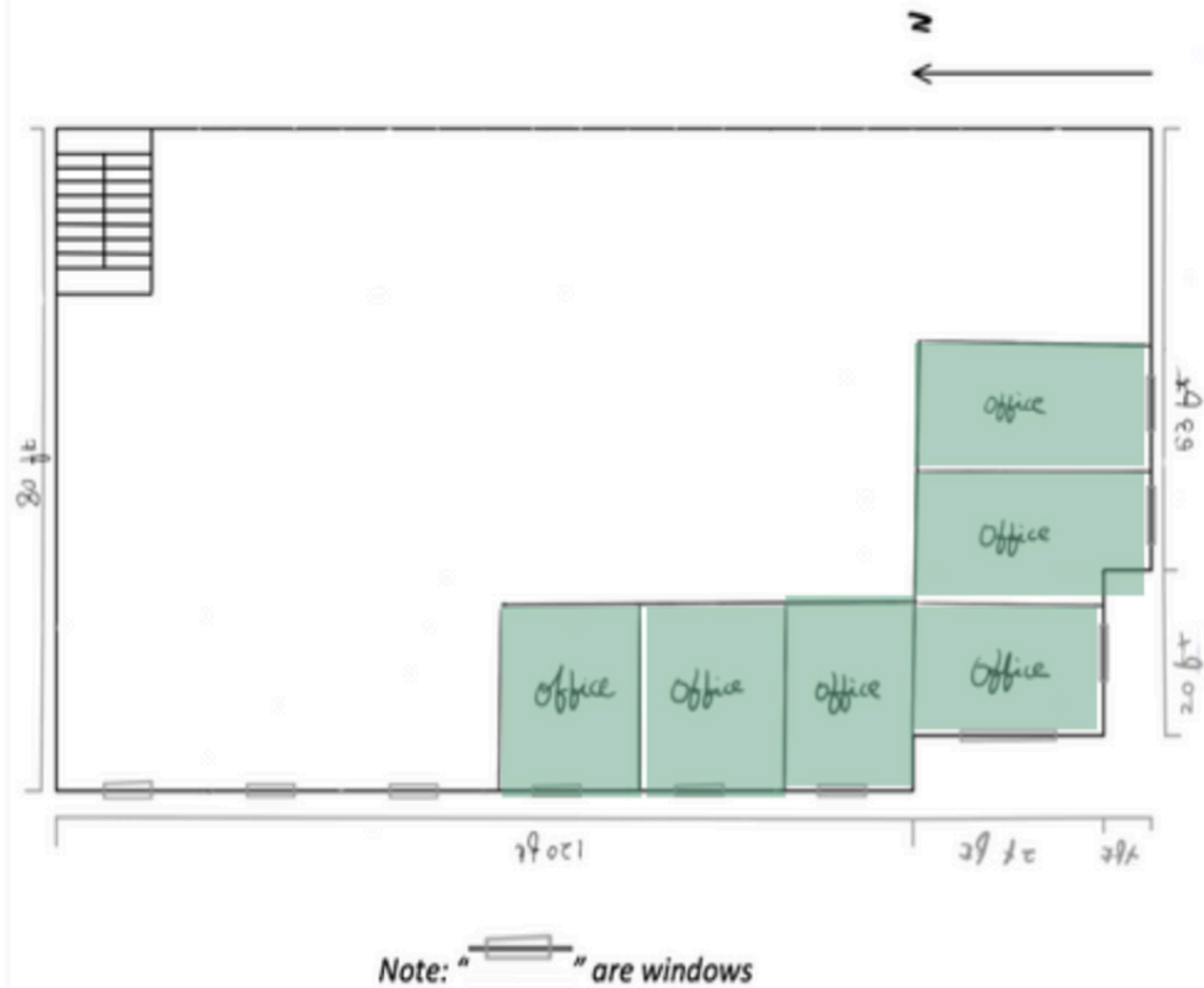
away from

between

User selected descriptor

System suggestions

Step 4: Specify the related entity



Internal employee space

should be placed **next to**

what?

office

work area

meeting area

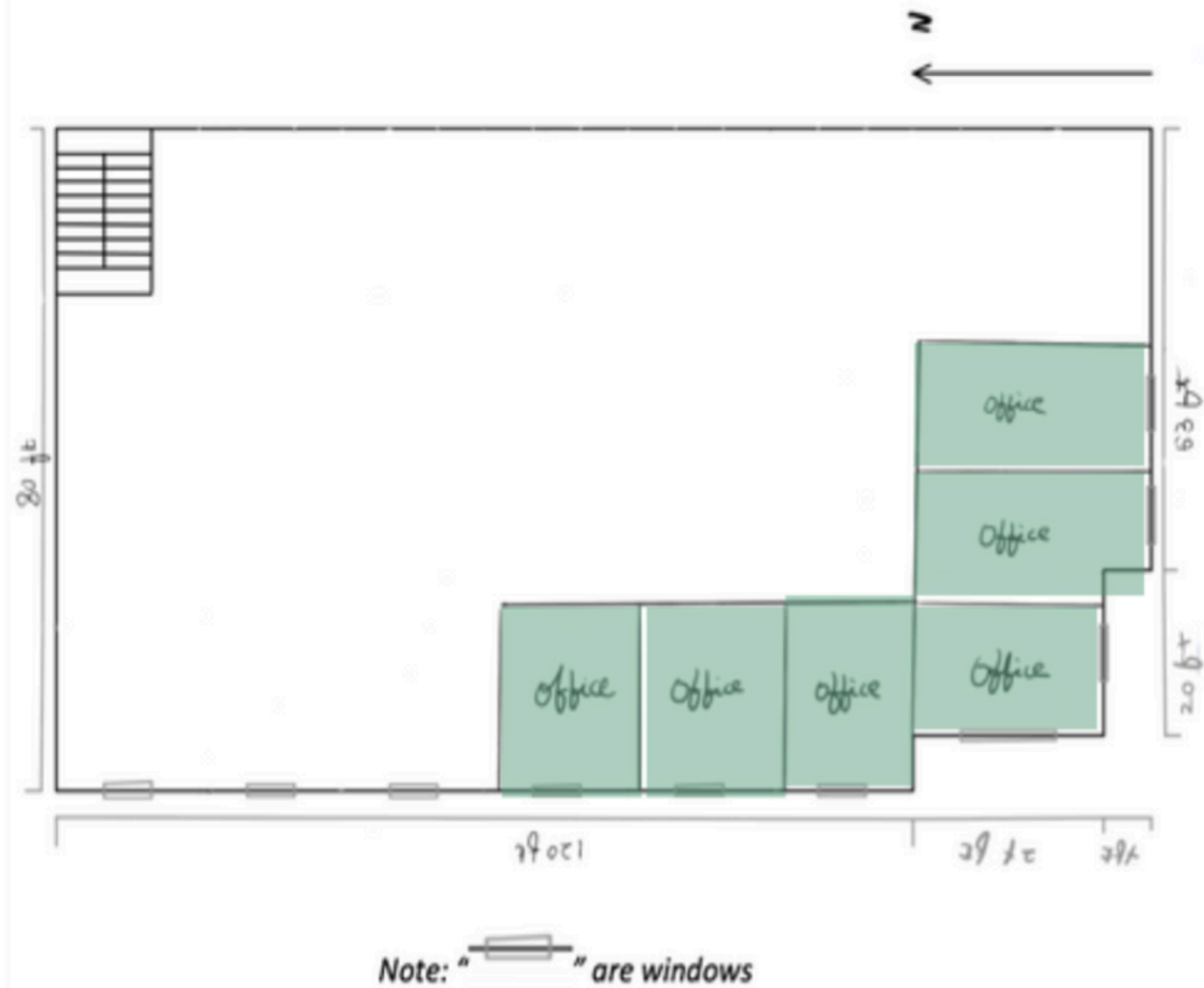
windows

+ add another rule

User can also input their words

System suggestions

*Step 5: add more rules



Internal employee space

should be placed **next to**

what?

office

work area

meeting area

windows

+ add another rule

**BACKEND:
LEARNING THE KNOWLEDGE**

1. VOCABULARY LEARNING

- ▶ Location descriptors
- ▶ Entities

1. VOCABULARY LEARNING

- ▶ Location descriptors (mostly pre-designed)
 - ▶ 1. A comprehensive list of descriptors

FIRST ORDER

In the north/south of the room
In the middle of the room
At the corner of the room

SECOND ORDER

Near _____
(Not far from _____
Close to _____)

Away from _____

THIRD ORDER

Between _____ and _____

1. VOCABULARY LEARNING

- ▶ Location descriptors (mostly pre-designed)
 - ▶ 1. A comprehensive list of descriptors **capable of disambiguation**

FIRST ORDER

In the north/south of the room
In the middle of the room
At the corner of the room

SECOND ORDER

Near _____
(Not far from _____
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Away from _____

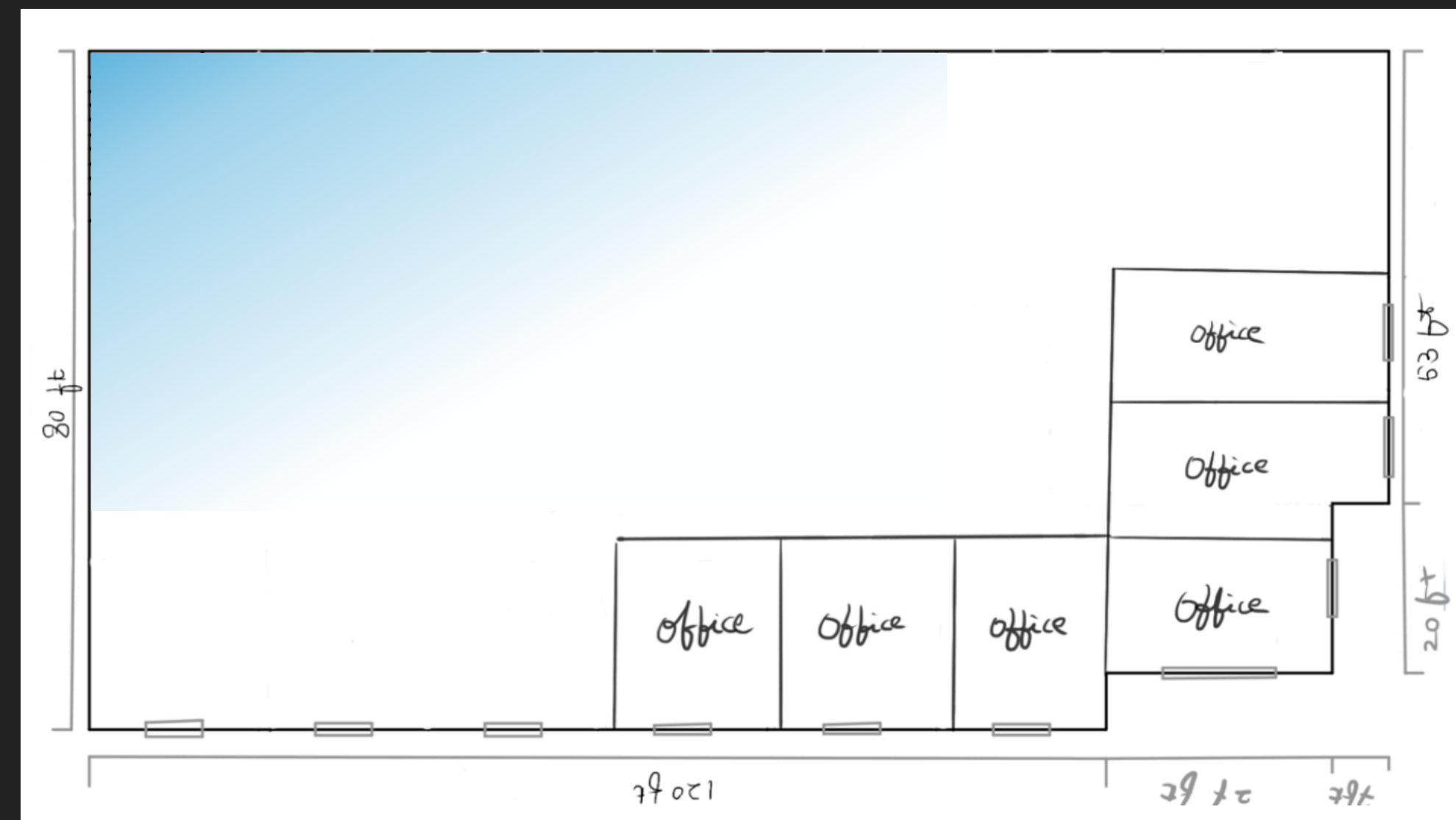
THIRD ORDER

Between _____ and _____

1. VOCABULARY LEARNING

- ▶ Location descriptors (mostly pre-designed)
 - ▶ 1. A comprehensive list of descriptors capable of disambiguation
 - ▶ *2. Mapping to the graphic floor plan

AWAY FROM OFFICE



1. VOCABULARY LEARNING

- ▶ Entities:

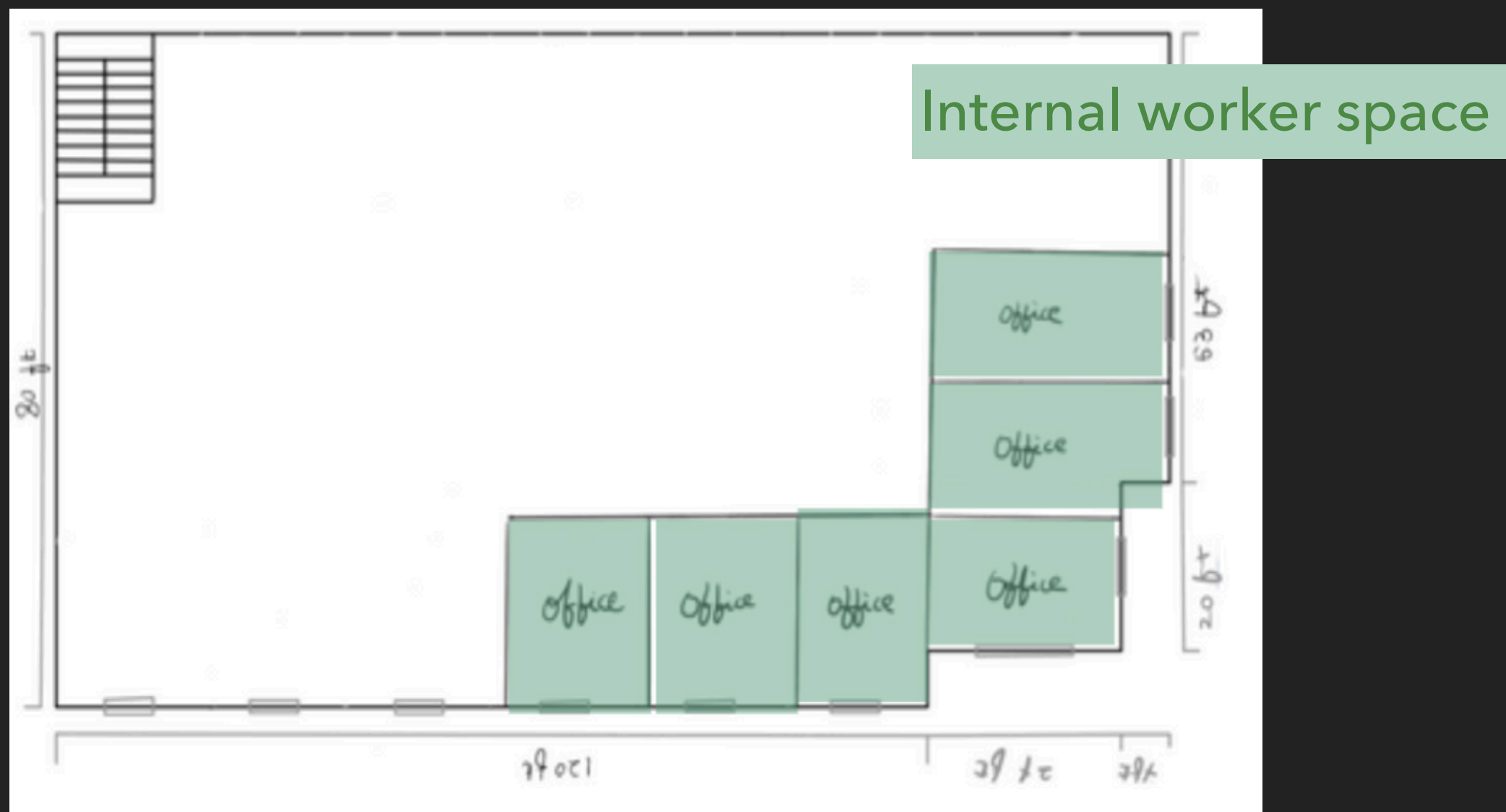
- ▶ Explicit entities: windows, stairs, offices, etc. (mostly pre-defined and read from the design)
- ▶ Implicit entities

LEARNING IMPLICIT ENTITIES

- ▶ Example: buffer space, chat area, high people density area, quiet areas
- ▶ Problem: overly big vocabulary thus hard to use rules
- ▶ Solution: spatial overlapping index (SOI)

LEARNING IMPLICIT ENTITIES

- ▶ Calculating spatial overlapping index (SOI)



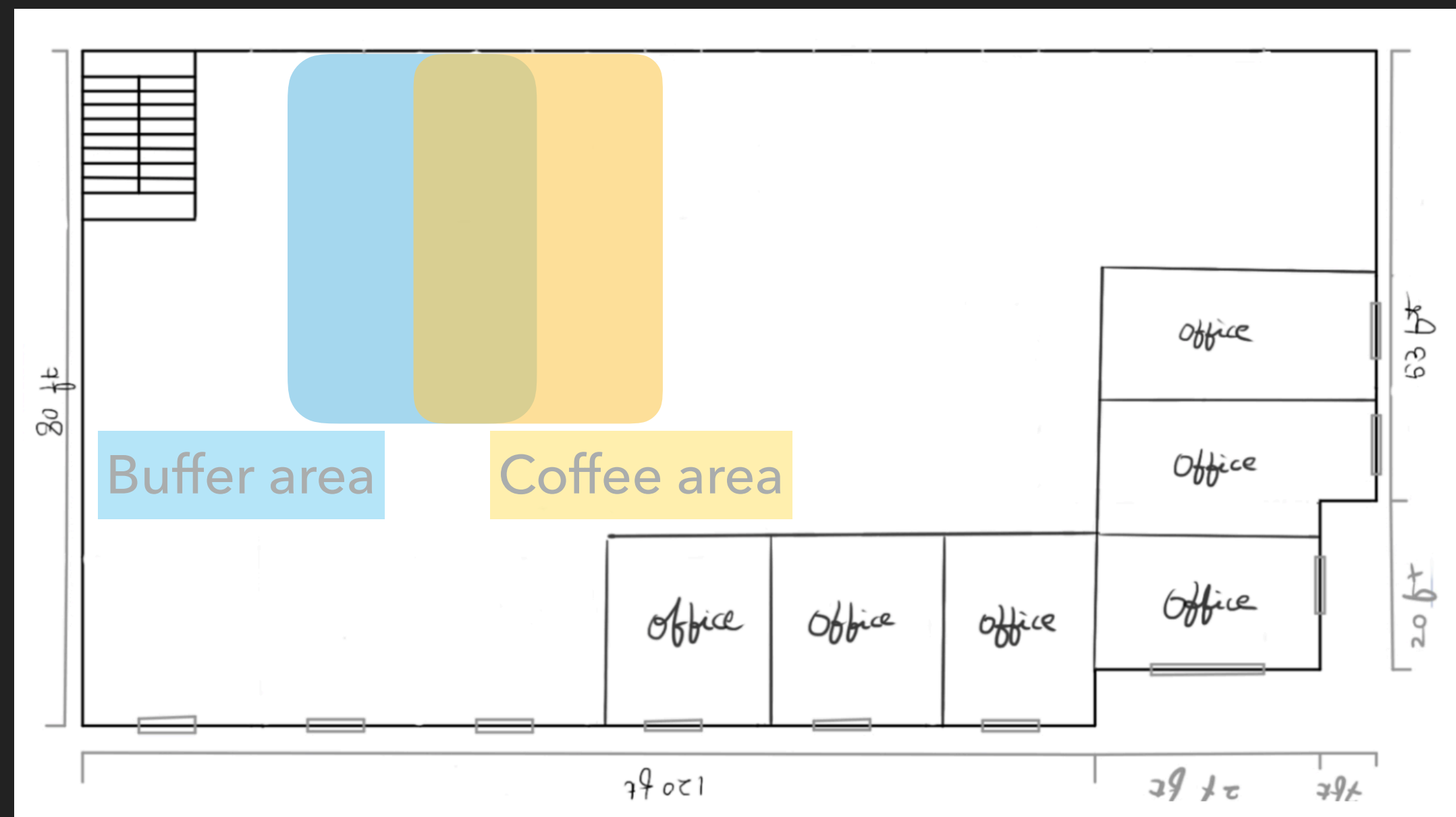
SOI = Intersection/union

In this graph:

$SOI(\text{office, internal space}) = 1$

LEARNING IMPLICIT ENTITIES

- ▶ Calculating spatial overlapping index (SOI)



SOI = Intersection/union

In this graph:

SOI(buffer area, coffee area) = 1/3

LEARNING IMPLICIT ENTITIES

- ▶ Calculating spatial overlapping index (SOI)



In the knowledge base:

$SOI(A,B)$ = sum of all graphs containing A and B at the same time
= correlation factor between the two entities

- ▶ High SOI indicates terms can be combined and reduced

Feedback or suggestion?

2. RULE LEARNING

- ▶ List of combinations between locations and entities
- ▶ Searchable by entities or by locations

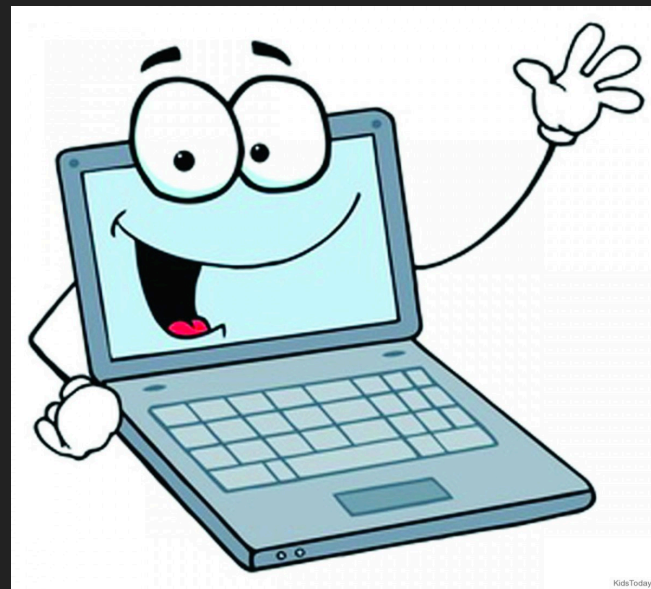
_____ should be placed close to the stair?

- Front desk
- Guest space
- Meeting room

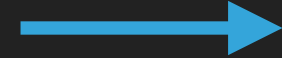
- ▶ "Specialized rule books" for different categories of designs (offices, shops, homes, etc.)

EVALUATION

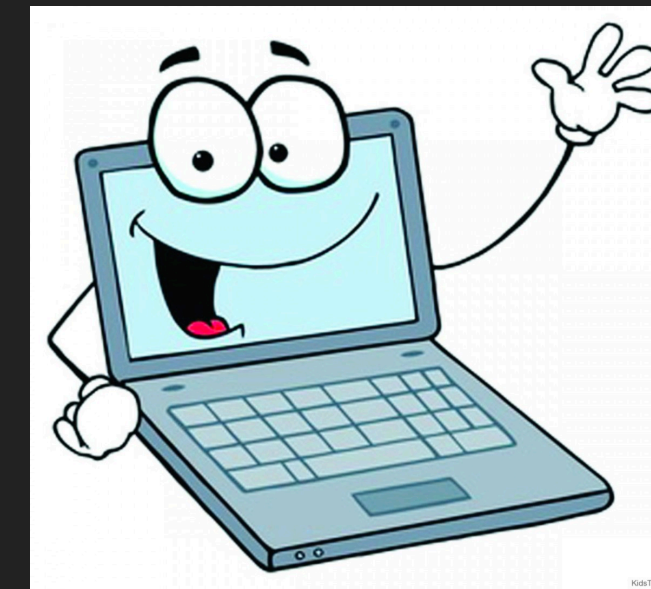
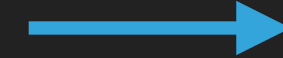
ITERATIONS OF DEVELOPMENT



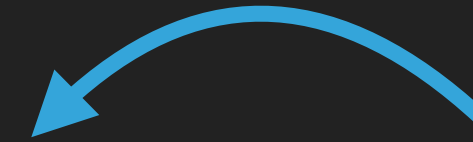
Build up basic vocabulary



User test & adding new terms



Incorporating user vocabulary



TWO INDEXES FOR EVALUATION

- ▶ 1. Ease of use
 - ▶ Less self-defined terms that new users input.
 - ▶ Less time needed for encoding per rule.
- ▶ 2. Usefulness of the knowledge base
 - ▶ Self-report, moderated interview sessions
 - ▶ Rule completion test

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User's answer

_____ should be placed close to the stair?
- Front desk
- Guest space
- Meeting room

EXTENSION:
GENERALIZING THE RULES

WHAT ABOUT RULES NOT IN THE FORM OF “ENTITY-LOCATION”?

- ▶ The existing vocabulary builds basis for further extension
- ▶ Example extension: causal design rules

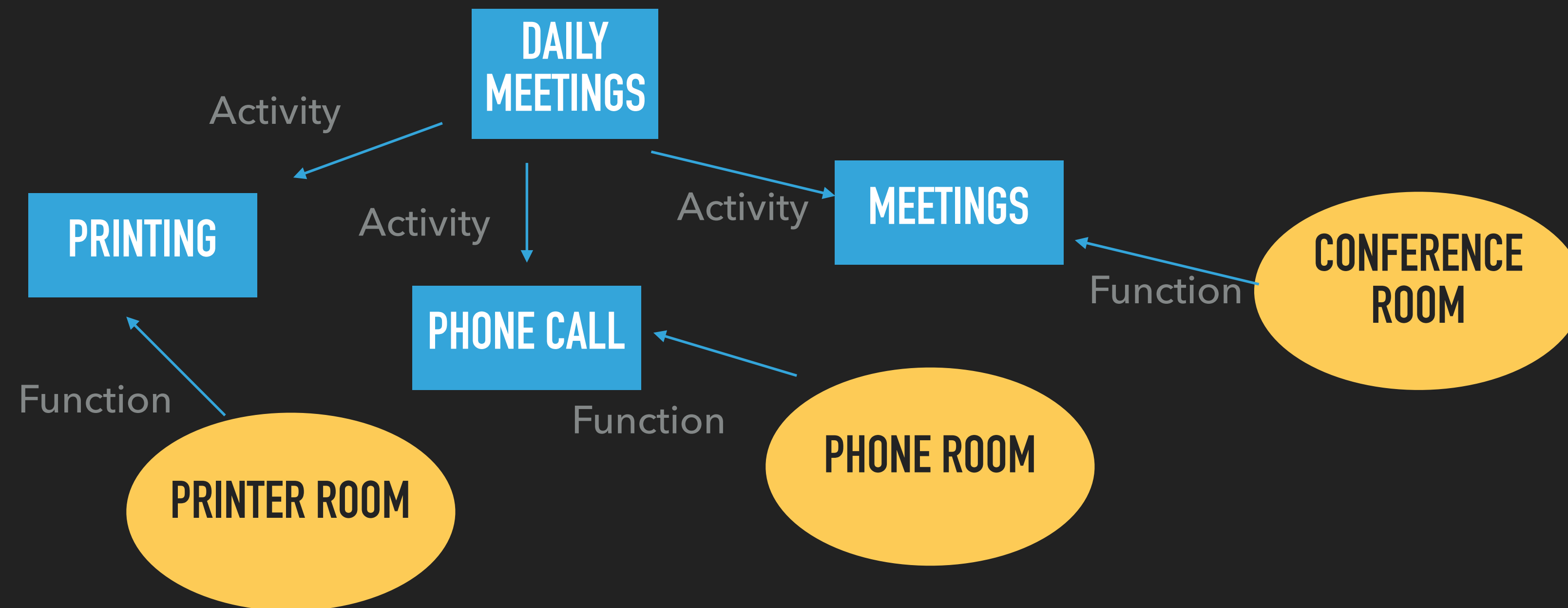
WHAT ABOUT RULES NOT IN THE FORM OF “ENTITY-LOCATION”?

- ▶ The existing vocabulary builds basis for further extension
- ▶ Example extension: causal design rules
 - ▶ 1 “work routine” motivated design

e.g. Phone rooms, printer rooms and conference rooms should be close to each other
so people can easily make phone calls or print documents during the conference.

"When ____ (people) do ____ (routine), they will need to do ____ (activities) at ____ (entity), ____ (activities) at ____ (entity) ..., so I put them together"

CAUSAL RULES



 = existing in basic vocabulary

 = added for new rule forms

WHAT ABOUT RULES NOT IN THE FORM OF “ENTITY-LOCATION”?

- ▶ The existing vocabulary builds basis for further extension
- ▶ Example extension: causal design rules
 - ▶ 1 “work routine” motivated design
 - ▶ 2 “value” motivated design

Office should be placed near the windows so it has more sunlights

“___ should be placed at ___ so it has more / less _____”

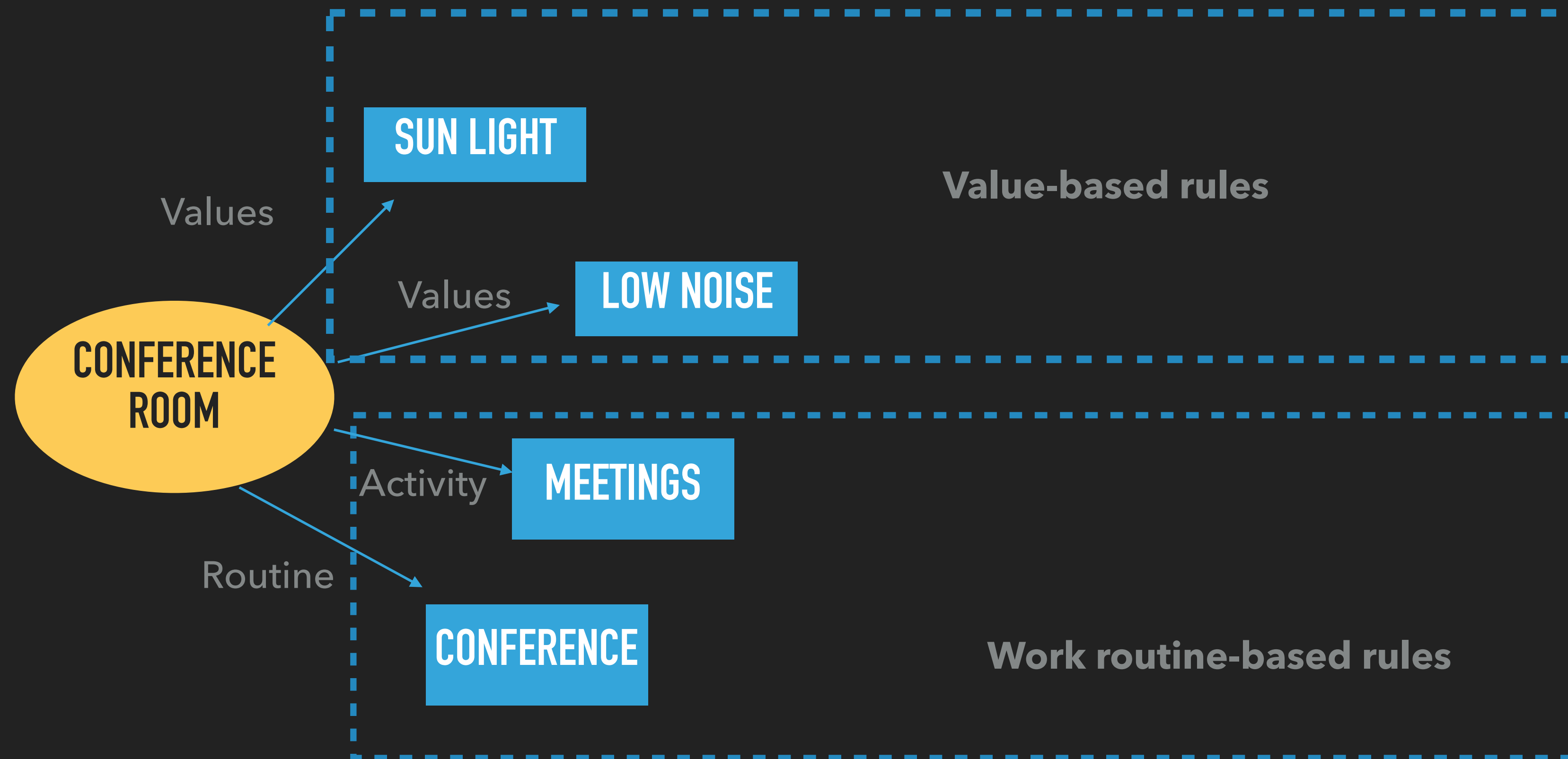
CAUSAL RULES



 = existing in basic vocabulary

 = added for new rule forms

CONCEPT = NAME + FEATURES



Infinite extension to new rules!

OTHER PROJECT EXTENSIONS

- ▶ Automatic intent detection
- ▶ Active learning for more efficient coding
- ▶ Unsupervised learning
- ▶ Learning from natural language data

AUTOMATIC INTENT DETECTION

- ▶ Step1: recognizing explicit entities and their spatial relations
 - ▶ Step2: recognizing potential implicit entities
 - ▶ Step3: match to the rule dictionary
-
- ▶ evaluation: for a new floor plan, compare the system detected intents and human report.

ACTIVE LEARNING

- ▶ Only ask the user to report when rules contradict.
 - ▶ E.g. Both offices and conference rooms should be close to the windows, how did you decide?
- ▶ Learn the priorities of rules / Extend to causal rules
- ▶ Higher efficiency for knowledge authoring!

UNSUPERVISED LEARNING

After the system is relatively complete:

- ▶ Give a “matching score” of how each design matches the current knowledges.
- ▶ The knowledge base should learn to optimize the matching score.
- ▶ No participant needed => Scale up the learning immensely!

LEARNING FROM NATURAL LANGUAGE DATA

- ▶ Extract entities and location descriptors from free-formed speech of designers explaining the intent
- ▶ Extraction guided by the existing knowledge base
- ▶ Utilizing much greater variety of data!

- ▶ Front end: Interface
- ▶ Back end: Learning
 - ▶ Location descriptors
 - ▶ Explicit and implicit entities; SOI
- ▶ Evaluation:
 - ▶ user experience
 - ▶ Knowledge base functionality
- ▶ Extension: Generalizing the rules
 - ▶ “Work routine” & “value” motivated design
 - ▶ Automatic intent detection
 - ▶ Active learning
 - ▶ Unsupervised learning
 - ▶ Learning from natural language data

THANK YOU!