

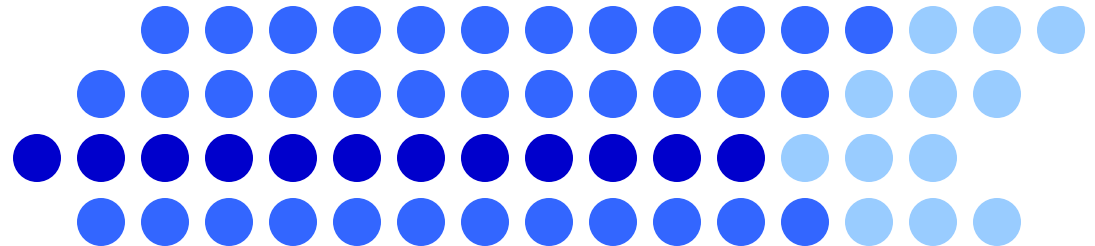
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A Proposal of Context-Aware Service Composition Method Based on Analytic Hierarchy Process

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Introduction



- Context-Aware Services
 - have been attracting attention as an approach to improving the usability of computer-mediated services.
 - are expected to become more effective and beneficial, especially in ubiquitous computing environments.
 - are used for meaning that specific services are provided for users' desired results according to the users' contexts.



Introduction



- Context is any information that can be used to characterize the situation of entities.
- For example:
 - Physical information
 - (ex.) User position, Noise, and Pressure.
 - User's information
 - (ex.) Taste, Habit, and Social interaction



Introduction



An example of
Context-aware services:



Context aware
mobile phone



The appropriate mean changes
according to user's context
(place, situation, ...).



In a train

→ To notify with **Vibrator**

At a living room

→ To notify with **Speaker**



Introduction



- The goal of context-aware service:

To provide smart support
anywhere, anytime, for everything.

- In this paper,
 - we propose a new service composition method with the analytic hierarchy process (AHP).
 - we discuss its availability and practicability, how it can deal with qualitative factor and treat wide variety of context entities.



Context-Aware Service Composition



- *Service composition:*
 - composing multiple combinable services, contents, and devices developed in advance, according to dynamically-changed contexts.

Context-aware service composition procedure:

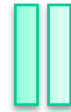
1. acquire some sort of data from circumstances with its sensors
2. determine service compositions and behaviors based on the contexts
3. combine service elements and control its service behaviors



Overview



Context-Aware Service Composition



To combine **context**, **service contents**, and **service/device elements** in real time

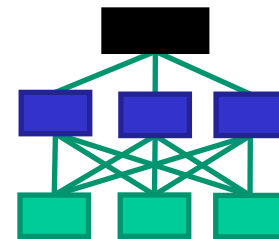
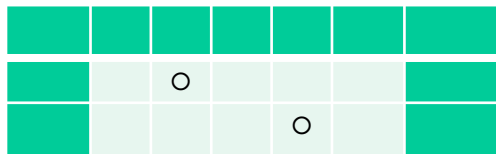
**With introducing the AHP,
we can systematically determine service
compositions and behaviors.**



Analytic Hierarchy Process (AHP)



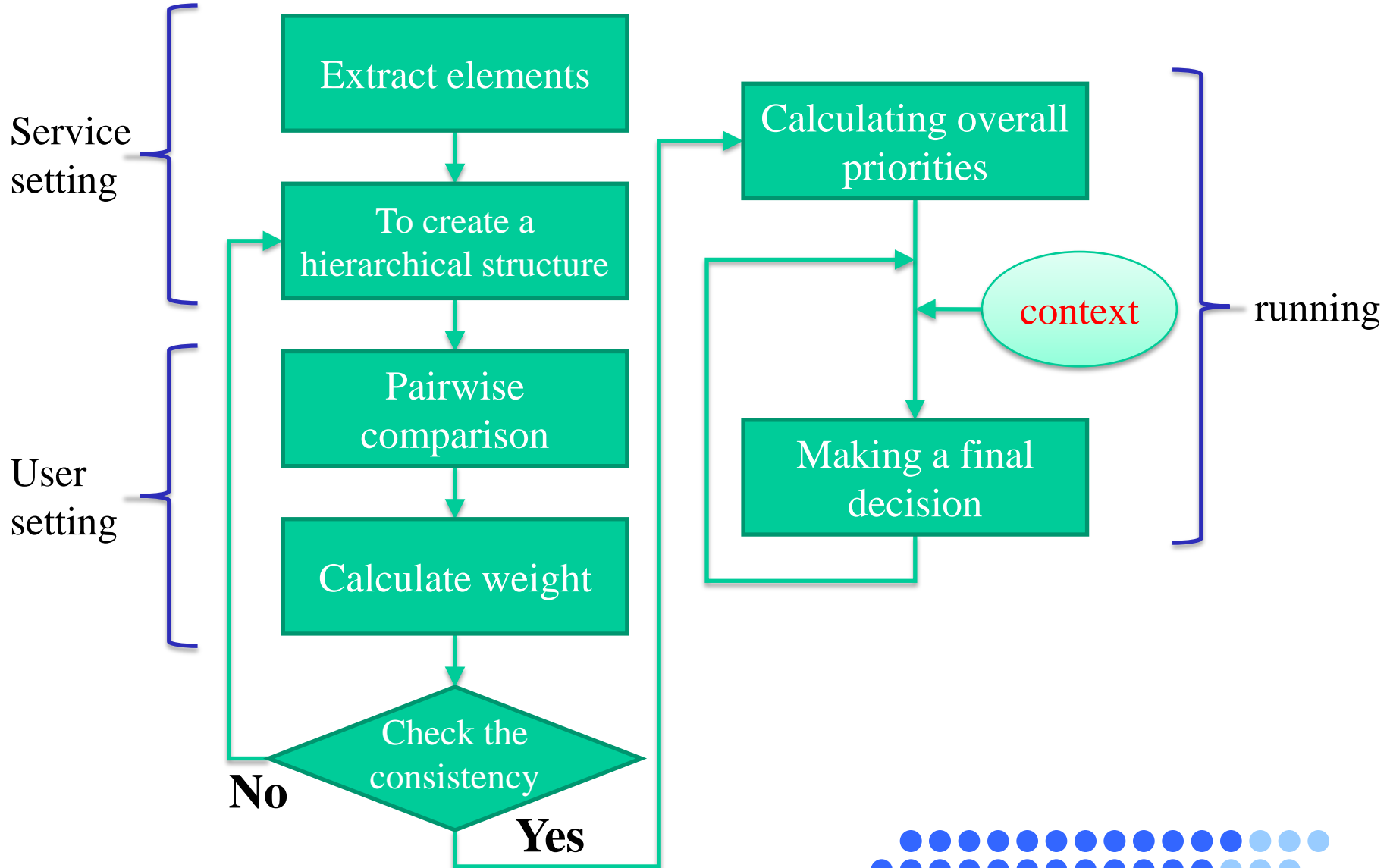
- The AHP [1]:
 - is a structured technique for dealing with complex decisions.
 - provides a comprehensive and rational framework for structuring a decision problem,
 - for representing and quantifying its elements,
 - for relating those elements to overall goals, and
 - for evaluating alternative solutions.



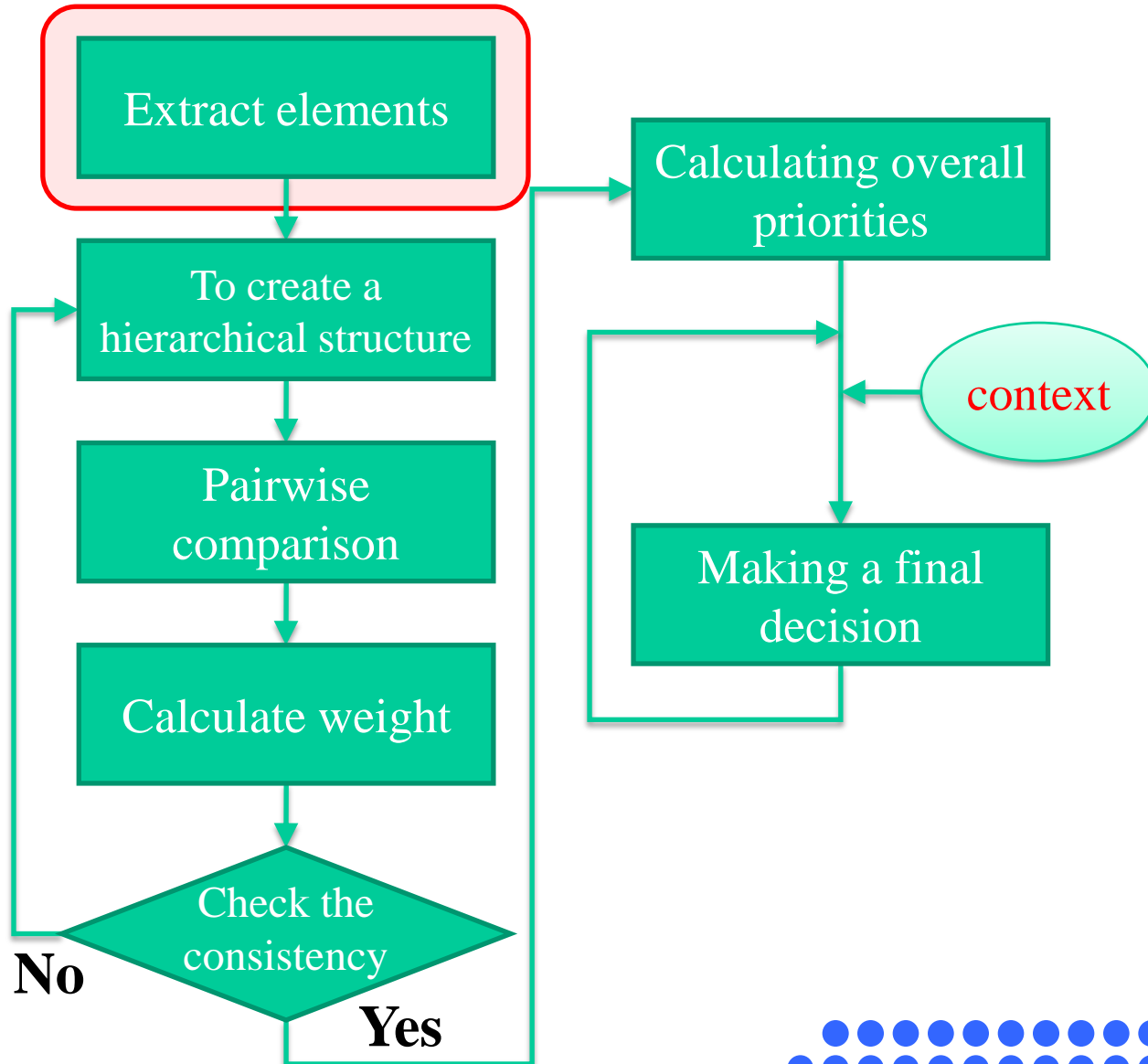
[1] T. L. Saaty, “The Analytic Hierarchy Process”, McGraw-Hill, 1980.



Context-Aware Service Composition Method



Context-Aware Service Composition Method



Extract Elements



- *Context* is
 - data all related services, and
 - obtained through the use of sensors.
 - (ex.) User context, and Physical context

(In this paper, we assume that sensors are able to obtain context information)
- *Service* is
 - a content that is provided for users, and
 - a goal in terms of AHP.
- *Service/device elements* are recombined.



Service Composition Example

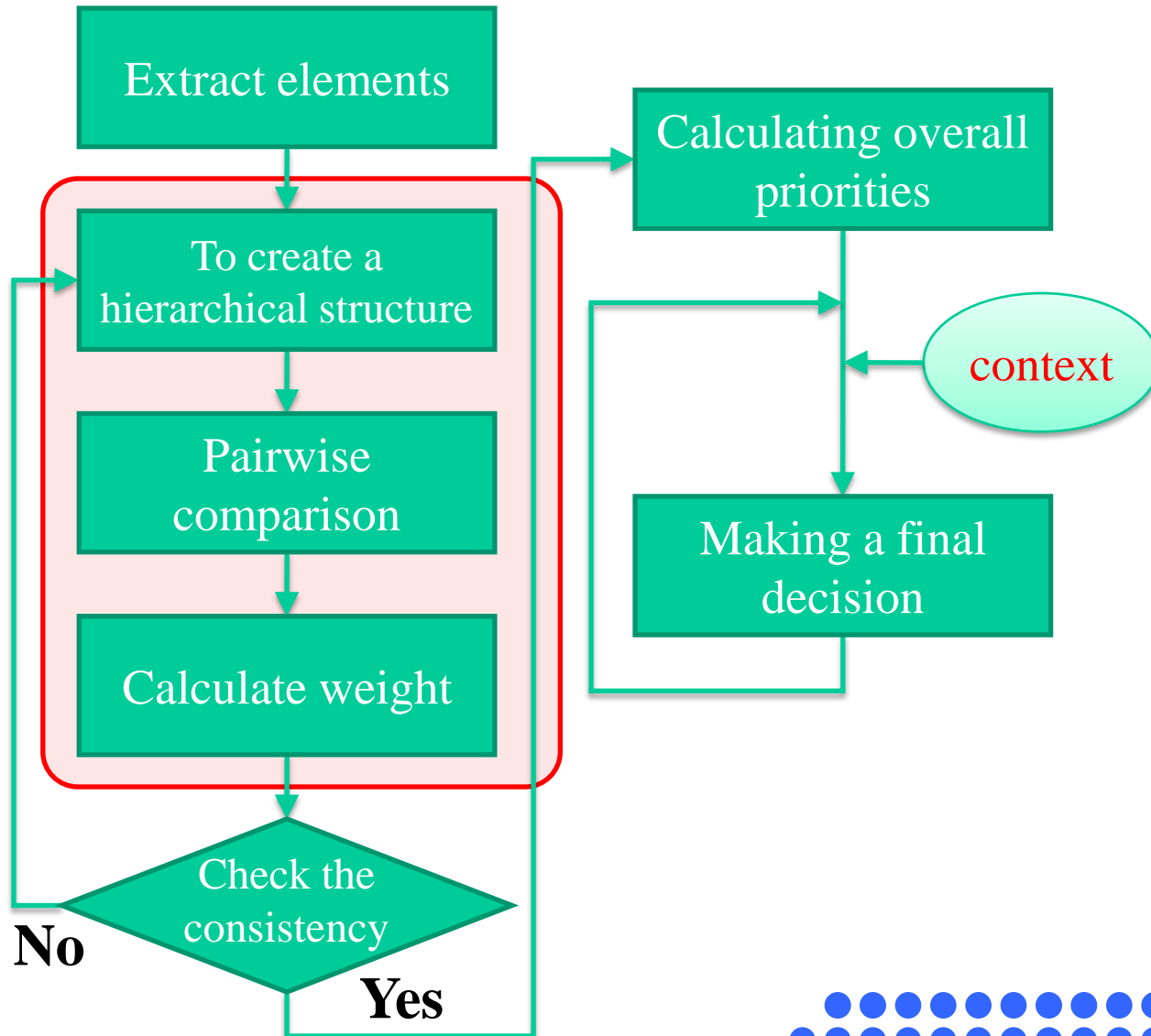


(ex) Context-Aware “to notify a user receiving phone call”

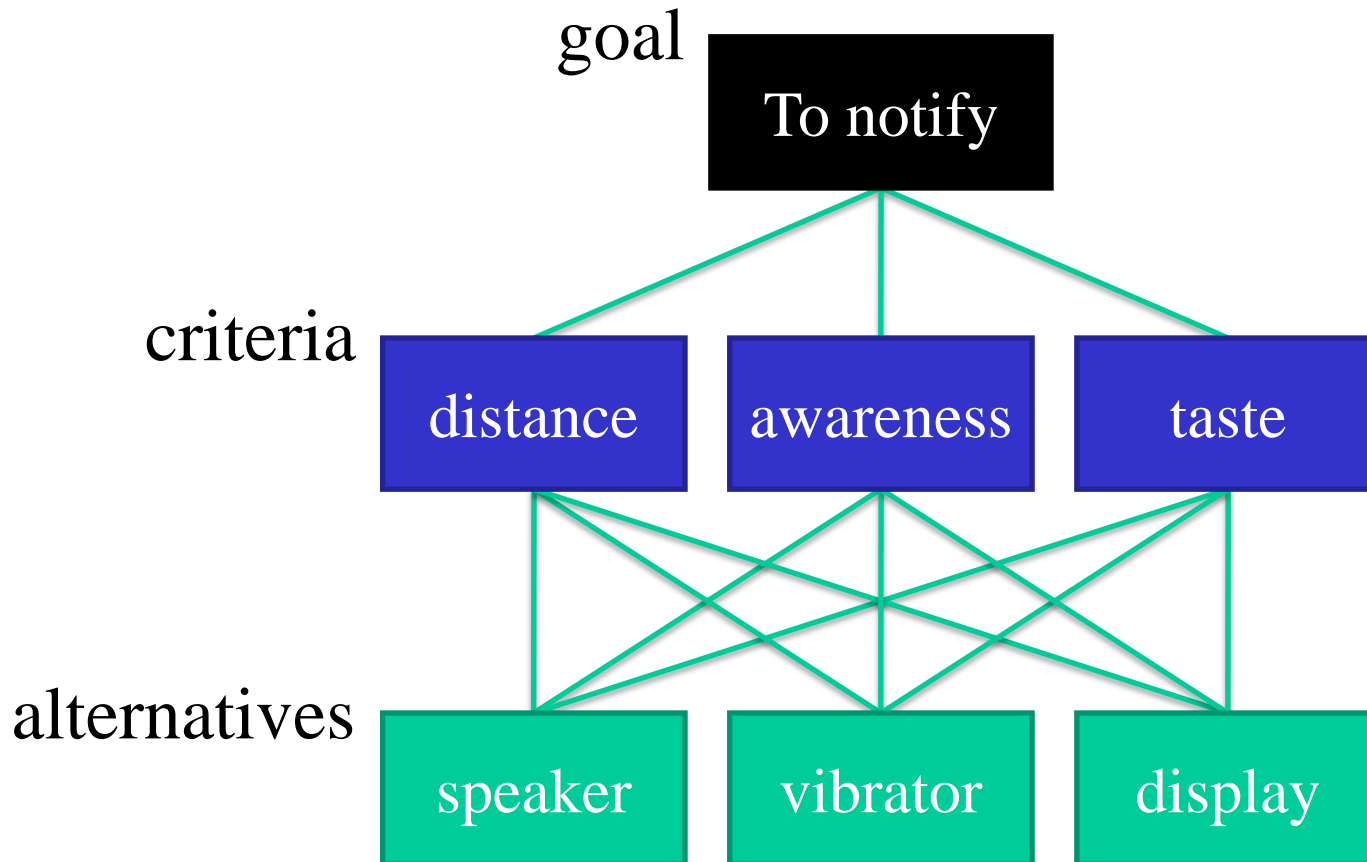
- Contexts affecting services:
 - Distance between user and device
 - Awareness (ambient noise, and user’s situation)
 - User’s tastes
- Service contents:
 - To notify a user receiving phone call (deciding the using device)
- Capable device to execute the services:
 - Speaker, vibrator, and display



Context-Aware Service Composition Method



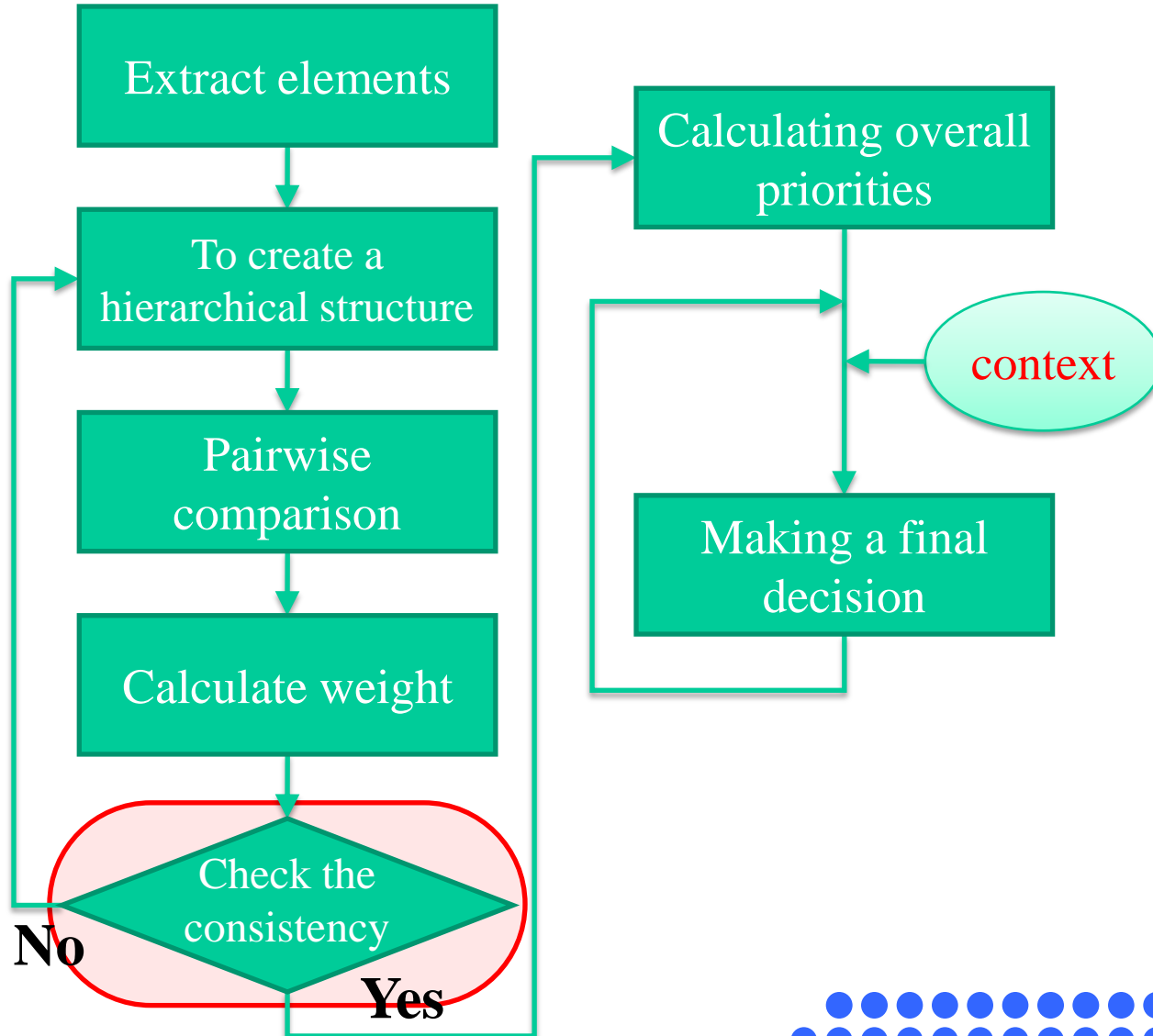
To Create a Hierarchical Structure



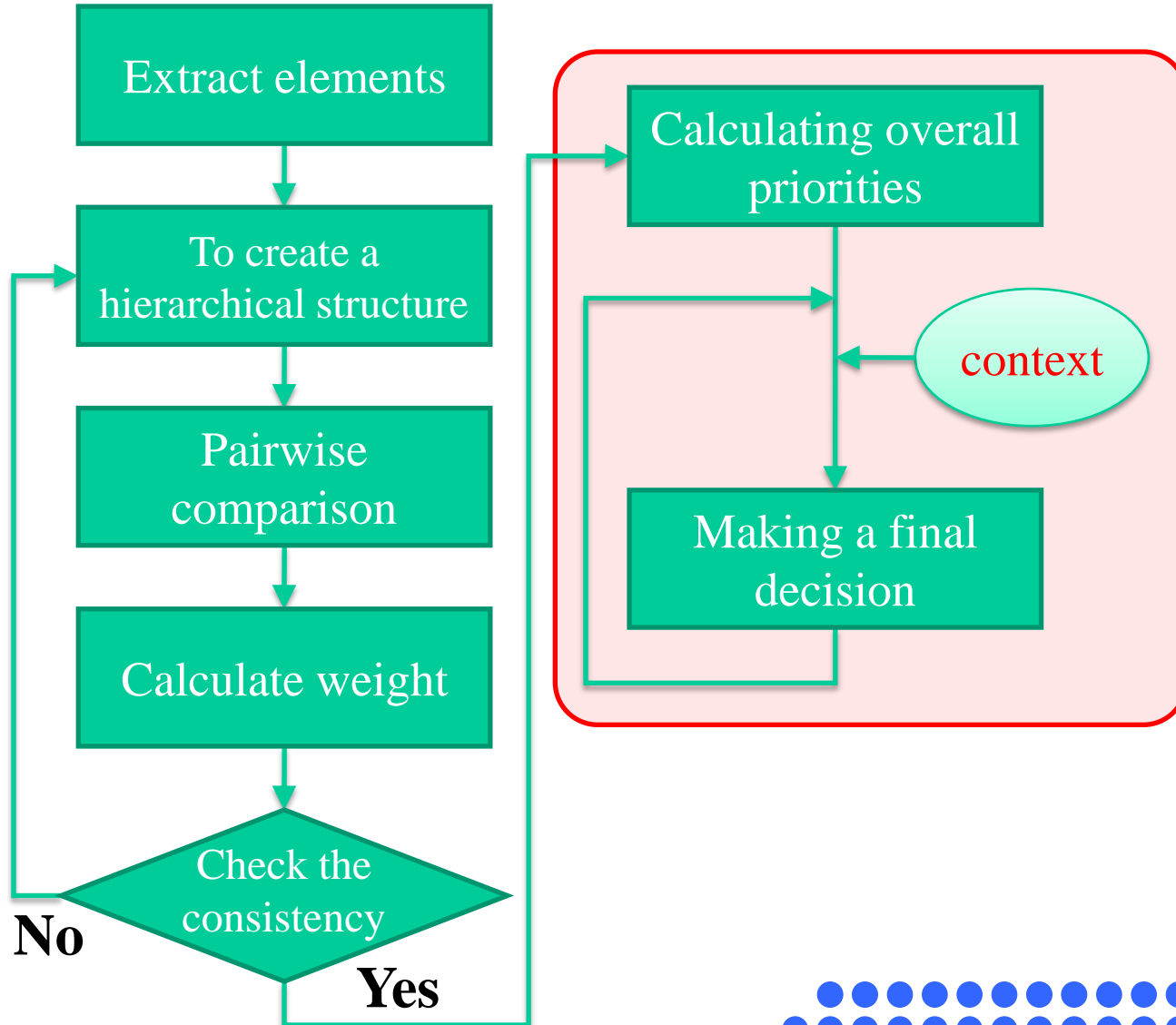
Abstracted elements decompose a hierarchical structure.



Context-Aware Service Composition Method



Context-Aware Service Composition Method



Calculating Overall Priorities

- Overall priorities are computed by multiplication of importance degrees of *alternatives*, *criteria*, and dynamically-changed *context data*.

$$X = \begin{bmatrix} x_{\text{Speaker}} \\ x_{\text{Vibrator}} \\ x_{\text{Display}} \end{bmatrix} = \begin{bmatrix} W_{\text{Distance}} & W_{\text{Awareness}} & W_{\text{Taste}} \end{bmatrix} CW$$

Importance degree of *alternatives* Dynamically changed *context data* Importance degree of *criteria*

X: importance degree of *goal* (overall priorities)

C: context data



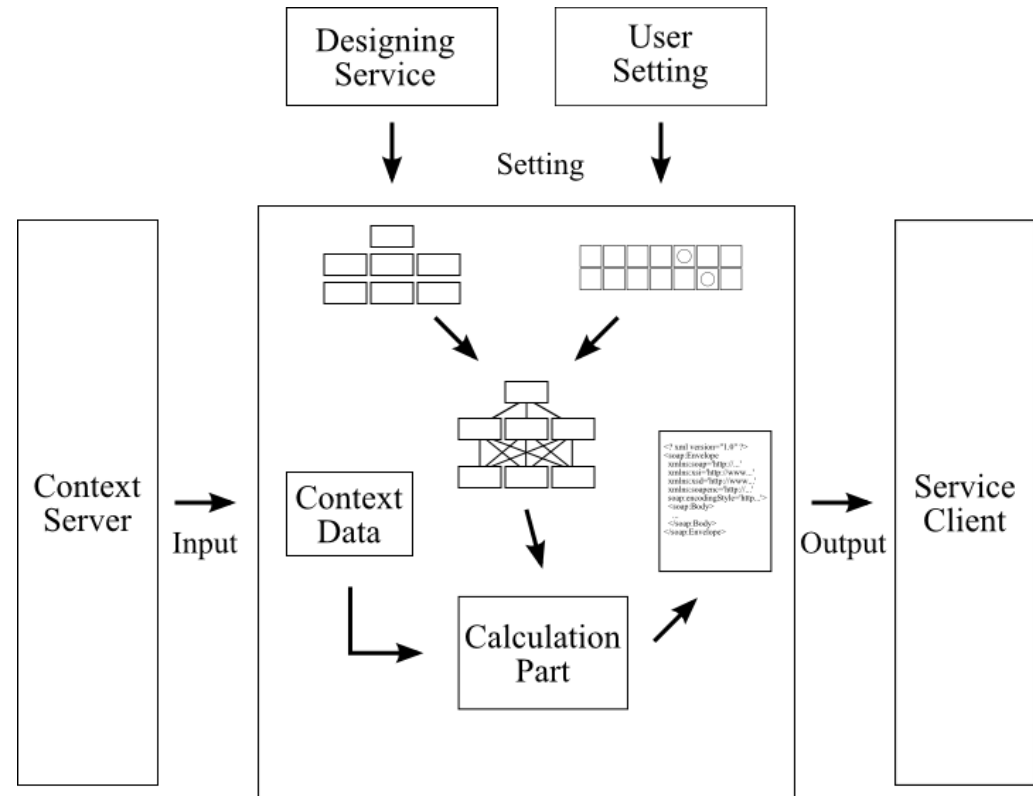
Prototype System (Overview)

- Input

- Designing Service
(service hierarchy)
- User setting
(pairwise comparison)
- Context
(changing in real-time)

- Output

- Service composition description



In this prototype system, context server and service client are virtual implementation.



Experiments (Setting)



- The prototype system calculate a representative service example of notifying a user receiving a phone call.
- We created pairwise comparisons by two representative users, as an input.
- We created virtual situations by using expressed value according to whether user-device distance is far or not, and user awareness level is high or low.
- We examined that whether each users' characteristic reflected the output, depending on the dynamically-changed context.



Experiments(results of User A)



To notify

To notify	1/9	1/7	1/5	1/3	1	3	5	7	9	
distance						○				awareness
distance							○			taste
awareness					○					taste

distance

distance	1/9	1/7	1/5	1/3	1	3	5	7	9	
speaker		○								vibrator
speaker		○								display
vibrator					○					display

awareness

awareness	1/9	1/7	1/5	1/3	1	3	5	7	9	
speaker					○					vibrator
speaker			○							display
vibrator			○							display

taste

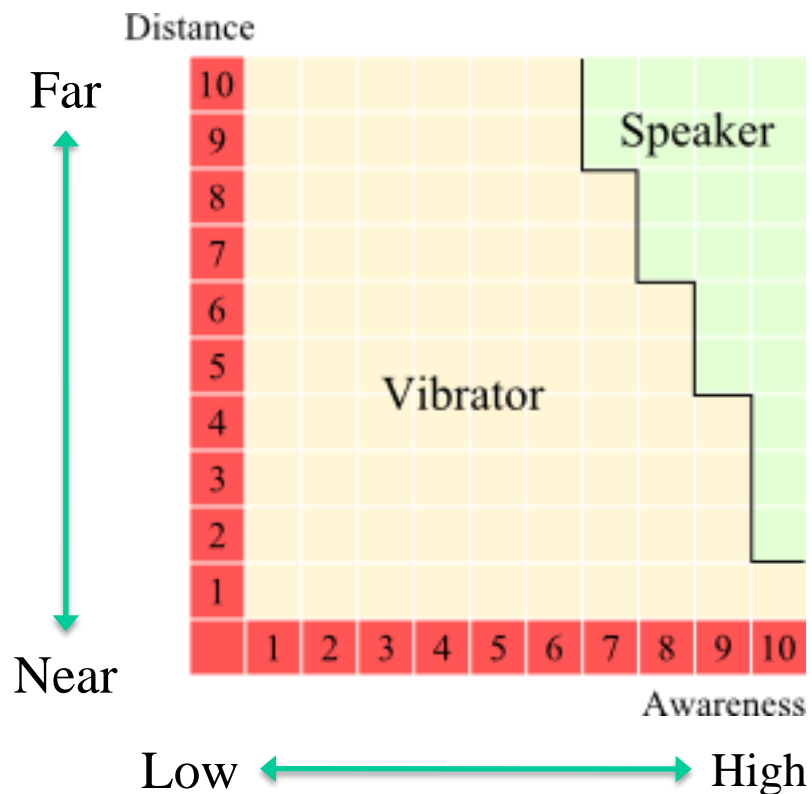
taste	1/9	1/7	1/5	1/3	1	3	5	7	9	
speaker					○					vibrator
speaker				○						display
vibrator			○							display

$$W_A = \begin{bmatrix} 0.1140 \\ 0.4054 \\ 0.4806 \end{bmatrix},$$

$$\begin{bmatrix} W_{Distance} & W_{Awareness} & W_{Taste} \end{bmatrix} = \begin{bmatrix} 0.6554 & 0.6491 & 0.0704 \\ 0.0549 & 0.2790 & 0.7514 \\ 0.2897 & 0.0719 & 0.1782 \end{bmatrix}$$

User A:

high regard of taste and awareness.
a taste for using vibrator.



Experiments(results of User B)



To notify

To notify	1/9	1/7	1/5	1/3	1	3	5	7	9	
distance							○			awareness
distance						○				taste
awareness			○							taste

distance

distance	1/9	1/7	1/5	1/3	1	3	5	7	9	
speaker			○							vibrator
speaker			○							display
vibrator					○					display

awareness

awareness	1/9	1/7	1/5	1/3	1	3	5	7	9	
speaker					○					vibrator
speaker				○						display
vibrator			○							display

taste

taste	1/9	1/7	1/5	1/3	1	3	5	7	9	
speaker						○				vibrator
speaker									○	display
vibrator								○		display

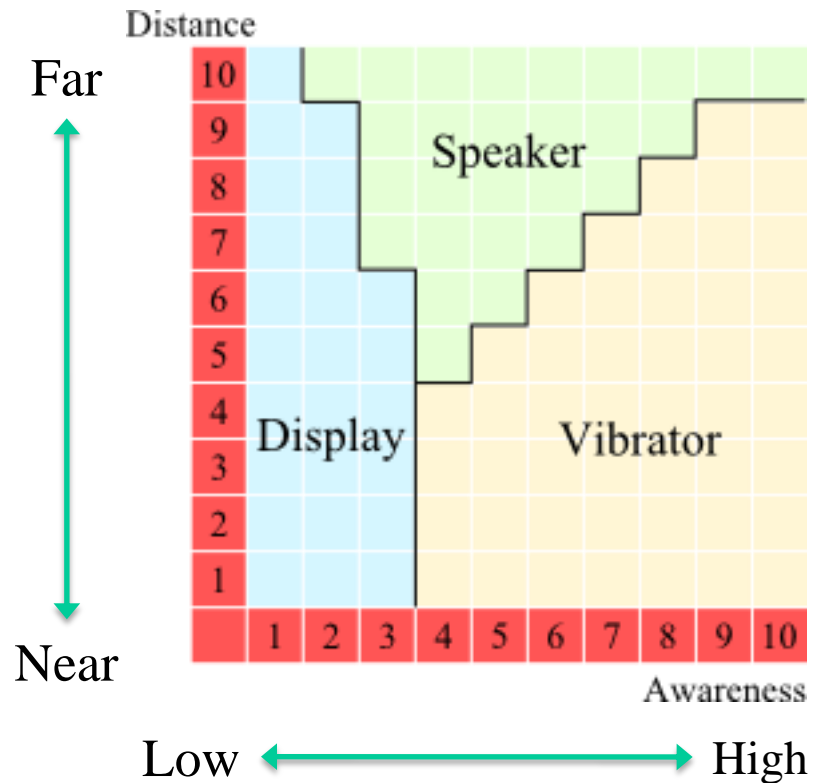
$$W_B = \begin{bmatrix} 0.1047 \\ 0.6370 \\ 0.2583 \end{bmatrix},$$

$$\begin{bmatrix} W_{\text{Distance}} & W_{\text{Awareness}} & W_{\text{Taste}} \end{bmatrix} = \begin{bmatrix} 0.7143 & 0.4054 & 0.0658 \\ 0.1429 & 0.4806 & 0.1488 \\ 0.1429 & 0.1140 & 0.7854 \end{bmatrix}$$

User B:

high regard of awareness.

a strong taste for using display.



Experimental result



- Consideration for experiments:
 - These outputs fit users' characteristic to some extent.
 - However, we need to carry out further investigations whether the boundary lines are correct.



Conclusion



- We have presented the method for context-aware service composition based on AHP, and implemented a prototype system.
- We have examined the availability of the method using sample data, and have confirmed that the method can output reasonable results for each sample context.



Future Work



- Further work is
 - to apply this method to real-world situations, such as home network, wireless mesh network, and intelligent building,
 - to compare it to other methods, and
 - to evaluate the effectiveness quantitatively.



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