The PSS representation diagram is given in Figure 7. As can be seen in Figure 7, the identified affordances played a role of linking the product elements to the service element. The conceptual sketch given in Figure 7 could be the best solution among a number of possible solutions obtained from the morphological matrix. It included the required affordance features. With the PSS concept given in Figure 7, the user can easily access to the umbrella output device and conveniently pick up the umbrellas by pulling out their handles. Since the subway station is usually very crowded, the passage structure that allows the users to smoothly move away with umbrella was also needed.

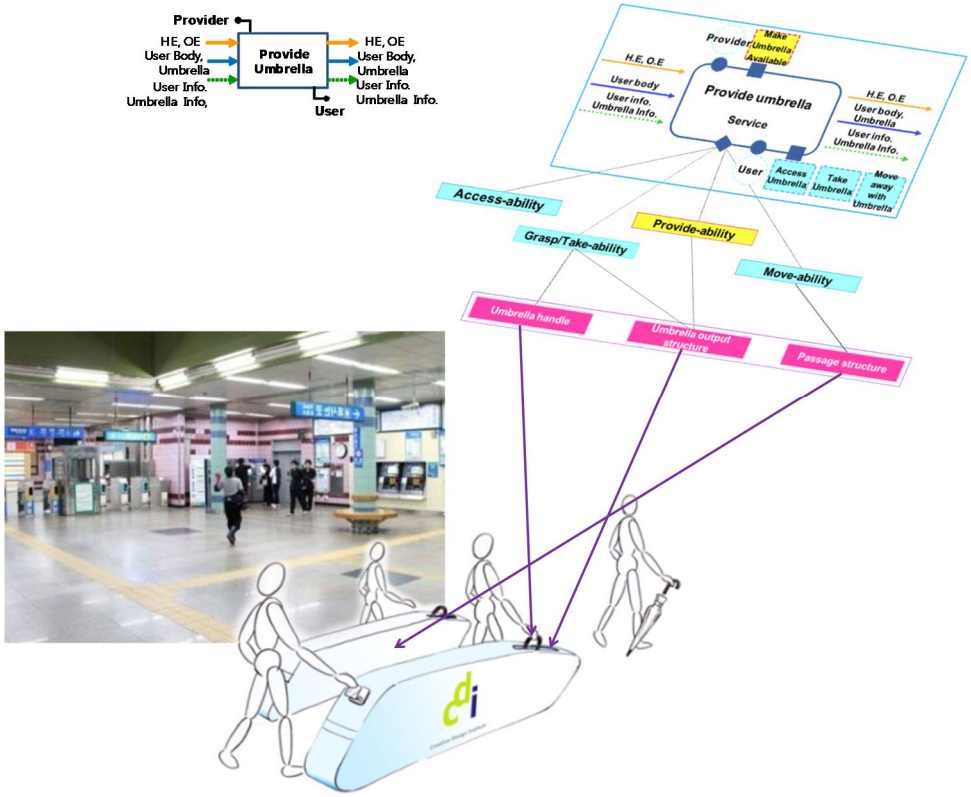

Figure 7 PSS representation for the function of 'provide umbrella' and the concept sketch of the product elements

In the second case example, the function of 'return umbrella' was considered. In this case, the associated activities were 'recognize umbrella', 'receive umbrella', 'arrange umbrella' and 'store umbrella' for the umbrella receiver and 'remove water', 'leave umbrella' and 'move away' for the returning user. Similar to the first case, the FAI matrix was generated and the affordances were identified, which is given in Figure 8. The identified affordances were 'identify-ability', 'receive-ability', 'arrange-ability' and 'store-ability' for the umbrella receiver and 'water remove-ability', 'leave-ability' and 'move-ability' for the returning user.

	SP				SR		
Function|Activity	Recognize umbrella	Receive umbrella	Arrange umbrella	Store umbrella	Remove water	Leave umbrella	Move away
Return umbrella	Identify-ability ◆	Receive-ability ◆	Arrange-ability ◆	Store-ability ◆	Waterremove-ability ◆	Leave-ability ◆	Move-ability ◆

Figure 8 Function–activity interaction matrix for 'return umbrella'

The PSS representation schematic diagram for the function of 'return umbrella' is given in Figure 9. The defined service element was 'return umbrella service', and the conceived product elements were the user identifier, umbrella input structure, umbrella waterspout, umbrella storage and passage structure. The conceptual sketch including the above product elements is also given Figure 9, which was considered to be the best solution among many alternatives. With the concept given in

Figure 9, the returning user could simply dry and insert the wet umbrella to the umbrella input structure without blocking the stream of other returning users. The inserted wet umbrella would be properly arranged and stored inside the device.

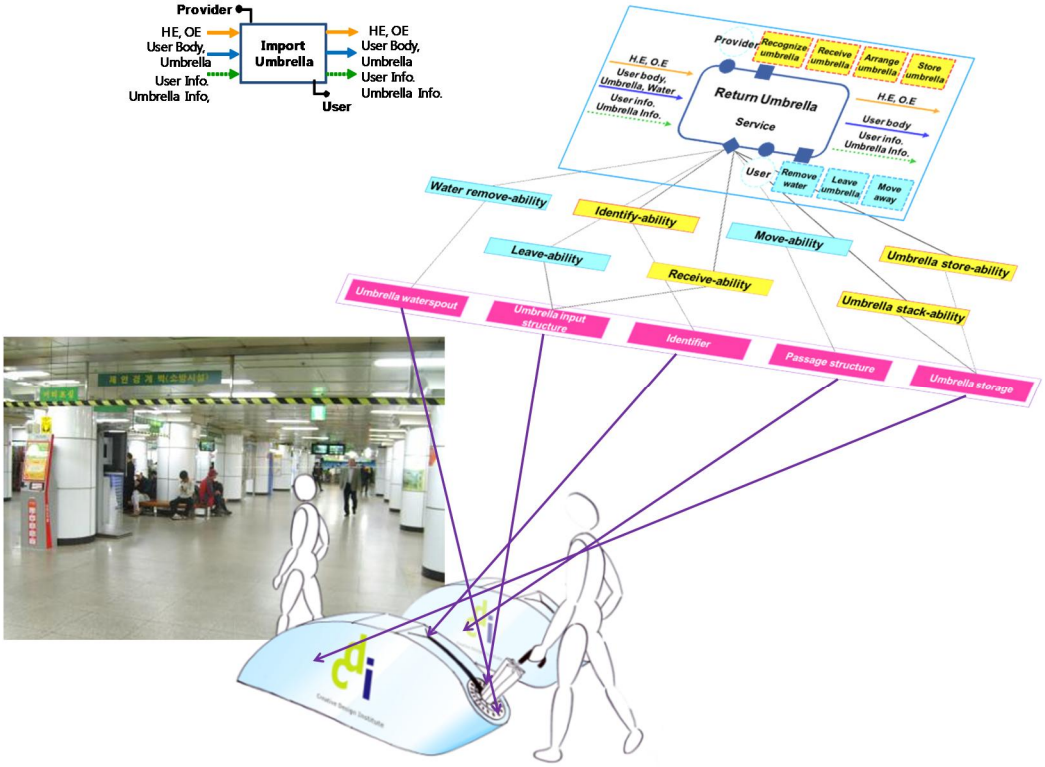

Figure 9 PSS representation for the function of 'return umbrella' and the concept sketch of the product elements

Conclusions

This paper presented the systematic design method for Product-Service Systems (PSS) by integrating service and produce elements using affordances in a service-dominant approach. In the PSS design method, the activities from the service blueprint and the functions from the PSS function modelling were combined in the service blueprint with function. Then, the pair of function and activities was selected, and the service element was defined. After defining the service element, the function-activity interaction analysis was conducted to identify essential affordances and affordance features. The morphological matrix approach was also used to explore the possible solutions including the required affordance features. Finally, the product elements were determined and their conceptual sketches could be generated to come up with the alternative PSS concepts.

In order to examine the effectiveness of the PSS design method, the case study of the urban umbrella rental PSS was conducted. In the case studies, the functions of 'provide umbrella' and 'return umbrella' were considered as representative examples, and the possible PSS concepts allowing the users to conveniently pick up and return the umbrella by including the essential affordances which were extracted from the FAI matrices were generated.

The PSS involves a number of stakeholders and their various activities. Therefore, it was confirmed that the usage of the affordances for integrating service elements and product elements was effective, since the affordance was the key property of the product elements that allows stakeholders' activities by its definition.

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