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'Anywhere to Work' An Implementation Method for Selecting Workplaces According to the Contexts of Workplace

Hitoshi KUMAGAI[a1], Naoki ISHIBASHI[a], Yasushi KIYOKI[a]
[a]*Graduate School of Data Science, Musashino University*

Abstract. In this paper, we proposed an implementation method of a system according to 'tri-knowledge base with personal context vectors model' that proposed in previous study. The system aims not only a single set of contexts and knowledge base, but also create snapshot and stored it as the memories of the changes in timeseries. Organisational contexts vectors were added to the system. As well as the personal context vectors to absorb personal preferences, the organisational context vectors can absorb organisational preference without changing the knowledgebase. Experiments were conducted to verify the functionality of memorising the changes in timeseries and the effects of the organisational context vector.

Keywords. Workplace, Active Based Working, Changes in timeseries, Organisational context

1. Introduction

'Workplace': where the present study focuses on

The study, including our previous study [1] and this paper, focuses on 'workplace'. Therefore, we again want to mention the recent problems of 'workplace'. Recently, the term is often used with wider means as places to work, which are not only conventional office, but also working from home, 3rd place such as café or public shared office, or others. Typical persons who use the workplace can be knowledge workers, and the number of knowledge workers has increased [2], and they are key players in economic society. Therefore, the preparation of the workplace for them has become more important.

Over the last 20 years, workplace settings have been changed. Since 2004, a Dutch consultant, Veldhoen [3] coined the term 'activity based working (ABW)', workplaces have been diverse and flexible. His established company, Veldhoen + Company, notes in their recent research [4] that: 'Active Based Working recognises that people perform different activities in their day-to-day work and therefore need a variety of workspaces, supported by the right physical settings and technology, to carry out activities

[1] Corresponding Author: Hitoshi Kumagai, Graduate School of Musasino University, 3-3-3, Ariake, Koto-ku、Tokyo, Japan: e-mail: g2251001@stu.musashino-u.ac.jp

effectively.', and the research[4] showed the improvement of the perception of the ABW adopted companies, for productivity, sense of community, and organisational culture

In the four years since the emergence of COVID-19, workplace circumstances have changed drastically. Remote work, especially work from home, has been more popular because of 'stay-at-home request'. A term 'hybrid work' has become common, which refers to the combination of working at the centre office[2] and remotely, even after the pandemic has settled.

Workers have now become more flexible for anywhere to work. However, this means that they must select more appropriate workplace for their productivity in complex situations. In addition, facility managers who are responsible for planning, implementing, and maintaining the workplace of an organisation, have more difficulties in planning the size, or workplace settings. We adopted again here a figure (Figure 1 [5]) from the previous research [1], which shows the recent problem of the workplace, and it is our basic motivation of the whole research of previous, this paper and the future works. For this problem, we are aiming to develop some evidence-based approaches rather than conventional conceptional or architectural approaches to solve the challenges of this complexity for both the workers and facility managers.

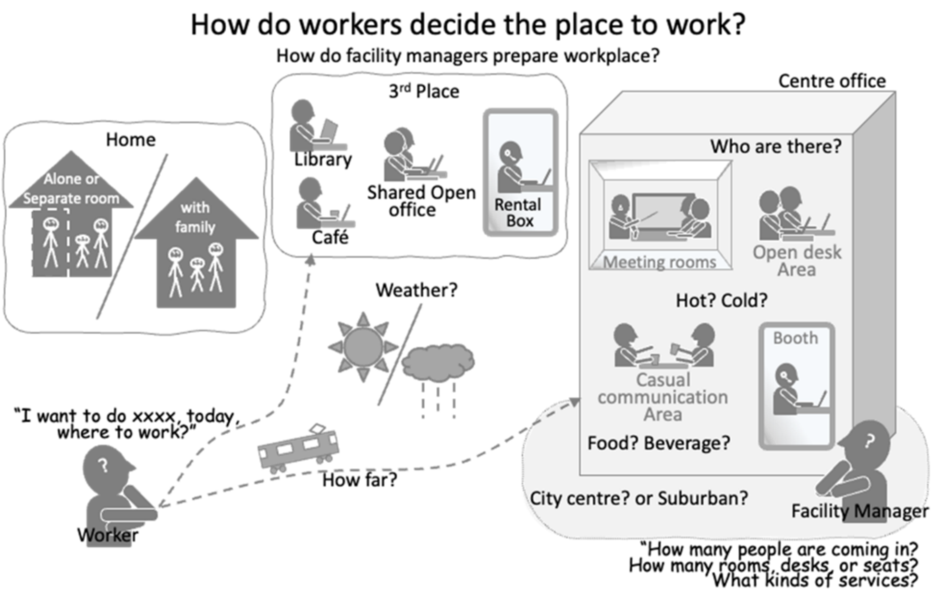


Figure 1. Problems of hybrid work. [5]

The research including this paper aims to explore a data model that describes behaviours and appropriate workplaces of the workers. The future objective of this research is to establish a workplace digital twin, where virtual workers work in a virtual workplace setting, which can predict the comfort and productivity of the workers.

The first step [1] of the research proposed a data model and a calculation method. The model and the method could result appropriate workplace for an intended activity of

[2] Centre office: is defined in this paper as; physical workplaces (offices) of an organisation, and this term is used objectively with remote work

worker in a certain set of the contexts. However, the method was limited to calculate only a single set of an intention and the contexts. Therefore, we tried to expand the method to a system which could calculate multiple sets of intentions and the contexts and could be enhanced for further context type or the option of the places. This paper proposes an implementation method to realise the calculation as a system.

2. Related research

In our previous study [1], we had defined 'the contexts of workplace' with semantic space model. Yokoyama et al. [6] presented a method that calculate the appropriate facility or service based on the dynamic contexts (intent/situation) of train passengers. The setting of their study was similar with the setting of workers and workplaces; thus, we had identified some static or dynamic intentions or situations of workers and workplace. We had defined in the study [1], at first, two type of primary contexts. The one is 'activities', such as, 'solo work with high concentration' or 'casual communication'. The other is 'places', such as, 'home office' or 'Open desk of the centre office;'. These two types of contexts can mutually be an objective variable or the explanatory variables.

Then, in our previous study [1], we had defined several complementary contexts, and we had found those contexts could be divided into two features. The contexts of the first type affect productivity of activities, such as 'phycological safety', and we named them as 'Activity affecting contexts'. And the others determine the place to work regardless of the activities, such as 'weather', and we named them as 'Place determining contexts. We adopted a figure [7] from the previous study [1] as **Figure 2** to show the structure of the contexts of workplace.

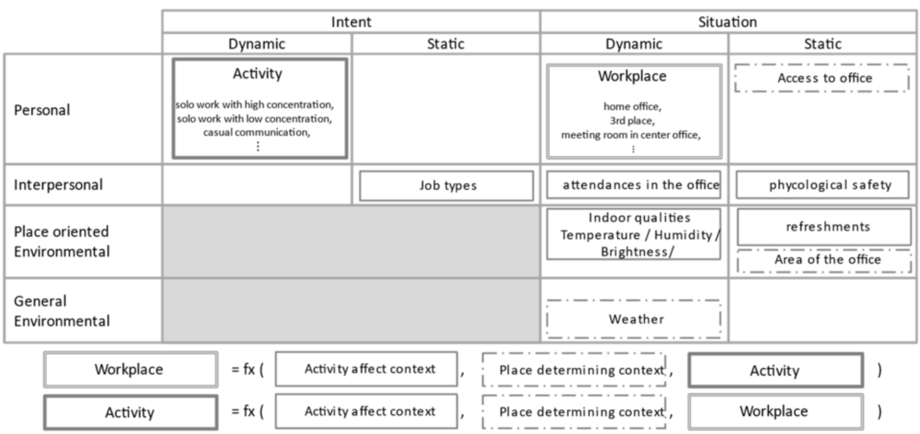


Figure 2. The contexts of workplace [7]

The aim of previous study [1] had been to propose calculation method for appropriate place to work when a worker intends to certain activity, or the opposite, the appropriate activity for a worker chosen place to work. We had proposed a method, named 'Tri-knowledge base with personal context vectors, which uses three knowledge bases according to three types of contexts as mentioned above, primary 'Place &

Activity', 'Activity affecting', and 'Place determining'. The method includes personal context vector to weight the personal impact on the contexts.

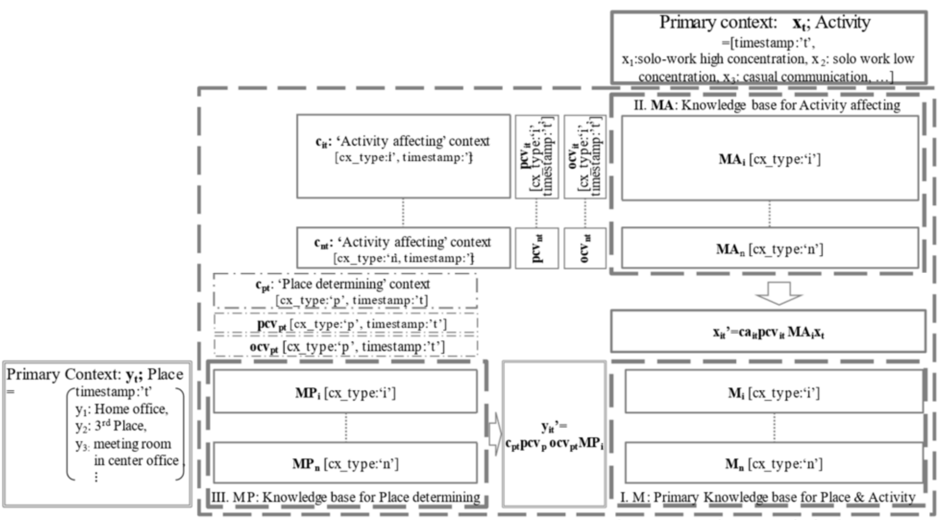
The method, proposed in the previous study [1], could calculate a result with only one set of contexts. Therefore, in this paper, we aimed to realise a system which can calculate multiple occasions. In addition, there are several challenges to using this system in a more realistic situation.

Firstly, we must consider the degree of influence of each context of the workplace. In the previous study [1], the degree had not been considered. The degree can vary from organisation to organisation. Some organisations may require more collaboration, and another may require more individual performance. The degree of influence must be adjusted by organisation.

Secondly, the system must consider changes in timeseries if it simulates in practice. Even in some static contexts, such as, the setting of drinks or snacks at the centre office, can be changed at some day. In addition, personal preference might be changed when a person is getting used to the work environment. Therefore, changes in timeseries must be memorised in the system.

Furthermore, we must simplify and be expandable for the system. In previous research [1], we had found some 'Activity affecting contexts' affect only in a certain place. Therefore, some activity affecting contexts had been calculated separately by places, then summed with general (none place dependent) and normalised. Whereas the calculation formular for each set of context vector and knowledge base matrix is same. Therefore, in this paper, we call the separation for the complementary contexts as 'context type' (abbreviating to 'cx_type'). For instance, the contexts for centre office are one of the context types. The place determining contexts are also treated as one of the context types.

Thus, we enhanced the 'Tri-knowledge base model' as **Figure 3**. We proposed, in this paper, the implement method into practical system for the 'Enhanced Tri-knowledge base model'



$$\mathbf{y_{it}=y'_{it}M_i x'_t= y'_{it}M_i\ ca_{it}pcv_{it}\ MA_i x_t= c_{pt}pcv_p\ ocv_{pt}MP_i\ M_i\ ca_{it}pcv_{it}\ MA_i x_t}$$

(i,n,p: context type (cx_type), t: timestamp)

Figure 3. 'Enhanced Tri-knowledge base model'

3. System architecture of 'Anywhere to work'

The system proposed in this paper is designed as shown in **Figure 4**. It consists of four main components, 0. Contexts collector, 1. User app, 2. Contexts snapshot creator, and 3. Knowledge base calculator.

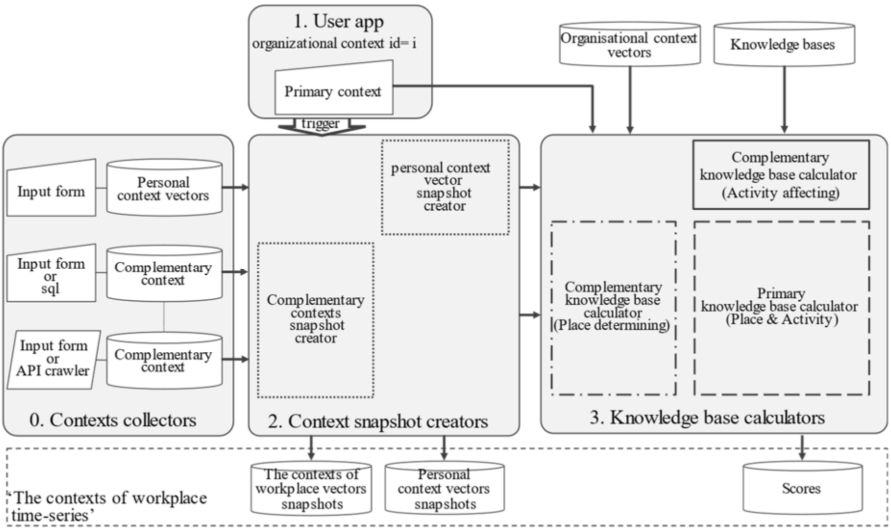


Figure 4. System architecture of 'Anywhere to work'

The calculation sequence of the components and brief functionalities are bellow, and the detailed functionalities of each component are explained in following sections.

0. Contexts collectors
   The contexts of workplace must be collected from different data sources. We prepared each collecting component to retrieve the data from each source. Each component collects data when each source is updated and stores the data into each database tables.

1. User app
   All contexts and knowledge bases calculations are triggered when a user selects their intending activity or place from possible options on this component.

2. Context snapshot creators
   This component, firstly triggered by the User app, collects the context data from the context database tables and creates a context vector as a snapshot per context type. The component hands over the snapshots to the next component as well as stores the snapshot into 'the contexts of workplace time-series' tables.

3. Knowledge base calculators
   The component, after receiving the context snapshots, starts to calculate the complementary contexts and knowledge base. Then the component calculates the scores with the primary contexts and knowledge base for user's intending activity or place selected on the user app. In addition, this component stores the score with the timestamp that is same as it of corresponding the context snapshots.

3.0 Contexts collectors

The sources of the contexts are dispersed; therefore, the system prepares each component which collects each context, and stores the contexts into each corresponding database table. Some components collect the contexts by a user input form; such as personal context vector. Some components have API crawlers to collect the contexts from web services or sensors, such as weather or indoor climate of the centre office.

In addition, some contexts must be predicted, such as room temperature for tomorrow. Therefore, some contexts collectors calculate the prediction, for instance, room temperature is defined from the average of last 5 working days.

Each contexts collector collects not only the actual value, such as '23°C' of temperature, but also classifies it into vector, such as '{1, 0, 0}' (**Figure 5**).

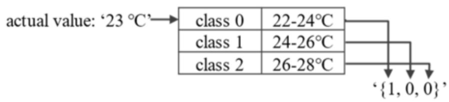


Figure 5. Vectorising a source value of a context

3.1 User app

This component is the trigger to start 'Anywhere to work' calculation. A user can select an intending activity or place to work as the primary context on this user app, and then the app triggers 'Context snapshot creators' and gives the primary context to 'Knowledge base calculator'.

User app also gives an id of the 'Organisational context vector' (here after it is called 'ocv'). The vector, added in this study, identify the weight of the contexts of workplace. The vector is unique for an organisation; therefore, a single id is assigned to a user when the user is registered.

3.2 Context snapshot creator

This component is the heart of this proposal. The contexts are not directory used for calculation but are set into a snapshot at the occasion of a calculation with target date-time, user id, and context type. The personal context vector is also set into snapshot. Those snapshots are stored in each snapshot database tables. The snapshot data can memorise the changes in timeseries of the contexts of workplace.

3.3 Knowledge base calculator

Finally, the contexts of workplace snapshots are calculated with knowledge base as shown in **Figure 6**.

a) Firstly, complementary contexts, personal context vector and organisational context vector by context type are multiplied.
b) Secondly, the calculated vectors are multiplied with a complementary knowledge bases of dedicated context type.
   Because the complementary contexts vectors and knowledge bases are divided into the contexts type, thus, a single component mechanism can conduct the calculation, and it allows the system to expand the complementary contexts.

c) Finally, each result is applied to the primary knowledge base; 'Place & Activity'. The scores of all possible places for a user's intending activity are calculated and sorted. As the same manner, the score for possible activities when the user intends to work from a place. These scores and ranks are not only shown to the user but also stored in the score database table with target date-time, intended activity or space. The database is also a memory of the changes in timeseries of Anywhere to work.

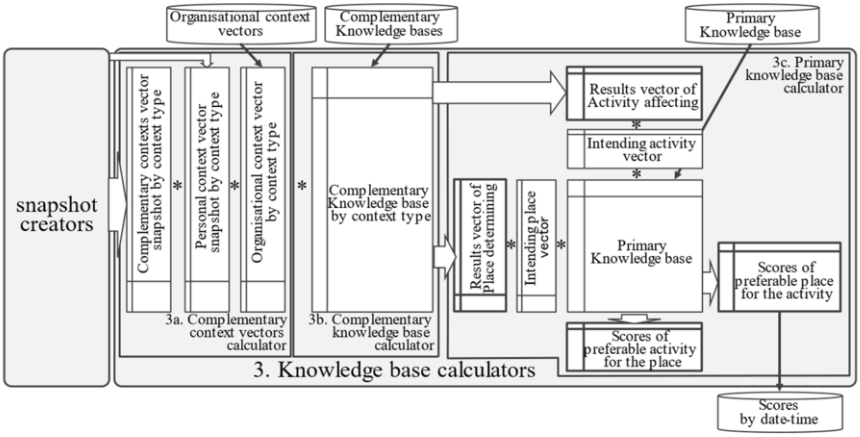


Figure 6. The mechanism of the knowledge base calculations

4. The system implementation

A prototype system was implemented according to the architecture mentioned previous chapter. It was intended that it would be used a company in Tokyo, Japan.

4.1 Prototype system architecture

Detailed architecture of the prototype system is shown as **Figure 7**. The detailed parameters of the contexts and knowledge bases are shown in following sections.

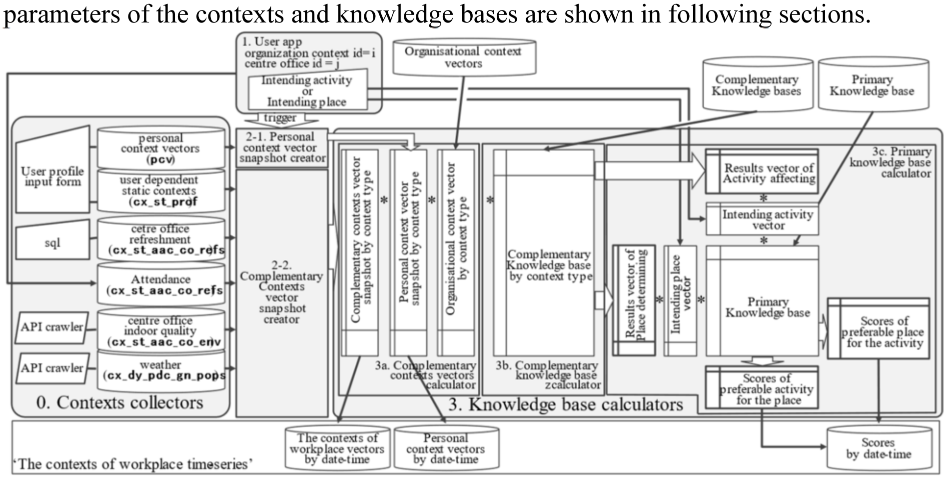


Figure 7. The detailed prototype system architecture

4.2 Activity and place

As the primary contexts, the options of 'Activities' and 'Places' are prepared as **Table 1**. The user of this prototype system can select one of the options on the user app as their intending activities or place to work.

Table 1. The selecting options of 'Activities' and 'Places'

Contexts	Selectable options
Activity (exclusive)	solo high concentration
	solo low concentration
	co-working
	casual communication
	meeting
Place (exclusive)	work from home
	favourite 3rd place
	a booth in the office
	an open desk in the office
	open communication in the office
	a meeting room in the office

4.3 Complementary contexts and contexts collectors

The complementary contexts, their options of this prototype, and the collecting way (contexts collectors), the name of stored database table, and context type name (cx_type) are shown in **Table 2**.

Table 2. The Complementary contexts, selecting option, contexts collectors and stored database table

Dependent place	Contexts	Options	contexts collectors	stored database table	cx_type
General (none place dependent)	Job type [total 100%]	➢ Administration [%] ➢ Coordinator [%] ➢ Business planning [%] ➢ R&D [%] ➢ Sales [%]	User profile input form	cx_st_prof	aac_gn
	Psychological safety level [exclusive]	➢ Very good ➢ Good ➢ Neutral ➢ Bad ➢ Very bad	User profile input form	cx_st_prof	aac_gn
Work from home	Circumstance at home [exclusive]	➢ Living alone ➢ Living with someone but have dedicated workplace ➢ Living with someone and no dedicated workplace	User profile input form	cx_st_prof	aac_ho
3rd place	Favourite 3rd place [exclusive]	➢ Open shared office ➢ Rental booth ➢ Café ➢ Public library ➢ Others ➢ None	User profile input form	cx_st_prof	aac_tp
Centre office	Refreshment; **drink**	➢ 1:(yes) ➢ 0:(no)	sql by administrator	cx_st_aac_co_refs	aac_co
	Refreshment; **snack**	➢ 1:(yes) ➢ 0:(no)	sql by administrator	cx_st_aac_co_refs	aac_co
	Refreshment; **meal**	➢ 1:(yes) ➢ 0:(no)	sql by administrator	cx_st_aac_co_refs	aac_co
	Attendance; **preferable people is there**	➢ 1:(yes) ➢ 0:(no)	User app	cx_dy_aac_co_ppl	aac_co

Attendance; **dislike people is not there**	➢ 1:(yes) ➢ 0:(no)	User app	cx_dy_aac_co_ppl	aac_co
Indoor quality; **temperature**	➢ 22-24℃ ➢ 24-26℃ ➢ 26-28℃	API crawler for sensoring system	cx_dy_aac_co_env	aac_co
Indoor quality; **humidity**	➢ 35-45% ➢ 45-55% ➢ 55-65%	API crawler for sensoring system	cx_dy_aac_co_env	aac_co
Indoor quality; CO2(ppm)	➢ 1 [<= 1000ppm] ➢ 1-(ppm-1000)/1500 ➢ 0 [>=2500ppm]	API crawler for sensoring system	cx_dy_aac_co_env	aac_co
Indoor quality; Illuminance on desktop	➢ Less 300Lx ➢ 300-600Lx ➢ Over 600Lx	API crawler for sensoring system	cx_dy_aac_co_env	aac_co
Weather; Probability of Precipitation (pop)	➢ 0% ➢ 0-40% ➢ 50% ➢ 60-90% ➢ 100%	API crawler for JMA[3] website	cx_dy_pdc_gn_pops	pdc_gn
Location of the centre office	➢ Very like ➢ Like ➢ SoSo ➢ Dislike ➢ Very dislike	User profile input form	cx_st_prof	pdc_gn
Commuting time	➢ In 30-mins ➢ 30 - 60 mins ➢ 50% ➢ 60-120 mins ➢ Over 120 min	User profile input form	cx_st_prof	pdc_gn

4.3.1 Target date-time of dynamic contexts

To simplify the system, the calculations were targeted twice a day, once in the morning and once in the afternoon. According to this, the data of all dynamic contexts, such as, indoor climates or weather are also targeted in the morning and in the afternoon.

4.3.2 User dependent static contexts

User dependent static contexts, such as, job type or circumstance at home, are input by the users themselves on 'user profile input form', when the user account registrations or anytime a user wants to change their profile. The form can be called from the user app. The contexts are vectorised and stored in 'cx_st_prof' database table, with username and context type. The user can also input personal context vector from this 'user profile input form'.

4.3.3 API crawler

The prototype system has two 'API crawlers'. One of them connects a weather forecast web site of Japan Meteorological Agency. The forecast is updated 3 times a day, and this crawler pulls the data of probability of precipitation(pop) just after updated the forecast, and the data of every am and pm for future 7 days are retrieved. The crawler vectorises the value as the context parameter, then stores the vector and actual values into 'cx_dy_pdc_gn_pops' database table.

[3] Japan Meteorological Agency

The other crawler connects a sensoring system of a company. The sensors detect indoor environment data: temperature, humidity, CO2 density, and illuminance. This crawler pulls those data every day at 10am and 15pm. Then the crawler calculates the average of 5 days in last 7 days of same timing. 2 days in last 7 days when the illuminance was the lowest and second lowest are assumed as day-off and the data is eliminated from the average. Finally, the crawler vectorises the average as the forecasted contexts parameter of future 7 days and stores the vector and actual values into 'cx_dy_aac_co_env' database table.

Those two context parameters are stored with 'coid' as well as the target date-time. The 'coid' indicates the centre office, and it is assigned to each user as their centre office. Therefore, the prototype system can treat multiple centre offices. All the other contexts which are centre office dependent (context type = 'aac_co') have 'coid'.

4.3.4 Attendance of preferable and dislike people

The prototype system does not have predicting function for the particular people attendance at the centre office. Therefore, the contexts are predicted by the users on the user app when they select appropriate activity or place, and the vectorised context parameters is stored into 'cx_dy_aac_co_ppl' database table.

4.4 User app

In the 'User app', a user can select an intending activity or a place to work for a target date-time, then trigger the calculation. After the calculation, the user can see the ranks of appropriate places for an intending activity, or the ranks of appropriate activities for an intending place to work (**Figure 8**).

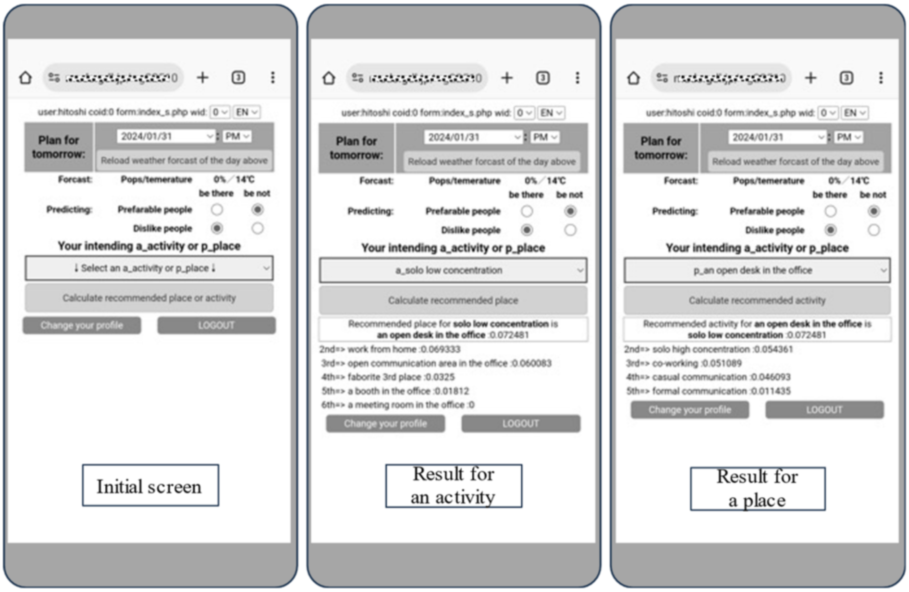


Figure 8. User app

4.5 Context snapshot creator

After a user starts a calculation, this 'Context snapshot creator' is triggered. The context snapshot creator collects contexts' vectors of targeted date-time for the user, from each database table, and concatenates into one vector by context type (**Figure 9**). The snapshot vector is stored into 'the contexts of workplace vectors by date-time' table and is transferred to knowledge base calculator. The place determining contexts are treated as same the activity affecting contexts as one of the context types ('pdc_gn').

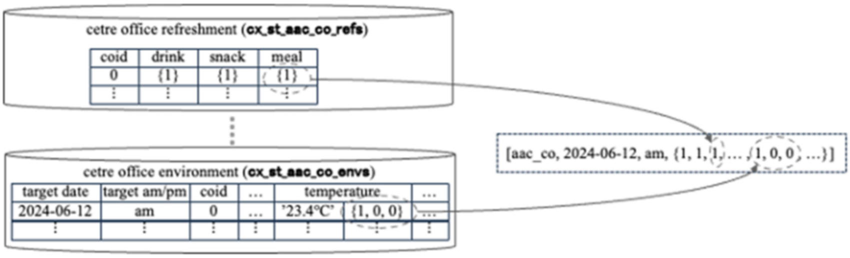


Figure 9. Concatenating contexts snapshot by context type

4.6 Knowledge base calculator

Knowledge base calculator consists of two modules, 'Complementary knowledge base calculator' and 'Primary knowledge base calculator'.

4.6.1 Complementary knowledge base calculator

In this module, the complementary context snapshot vector, the personal context snapshot vector, and the organisational context vector by corresponding context type are multiplied, then multiplied by the same context type knowledge base (**Figure 10**). The results vectors are transferred to Primary knowledge base calculator.

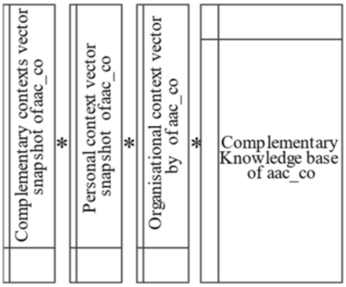


Figure 10. Example (for cx_type: aac_co) of Complementary knowledge base calculation

4.6.2 Primary knowledge base calculator

There are three parts in this module (**Figure 11**). Firstly, in this module, calculated vectors in previous module of 'general (none place dependent)' context type and each 'place dependent' context type are summed and normalised. In the prototype system, this normalisation is done by the way that the summed vector is divided by the sum of the elements of the organisational context vectors of the general and dedicated context type.

Secondly, the normalised vectors of both Activity affecting and Place determining are multiplied by Primary context (intended activity or place) and Primary knowledge base.

Finally, the results as the score of each place (for intending activity) are descending (appropriately) ranked, or each activity (for intending place) are descending (appropriately) ranked. The scores and the appropriate ranks are returned to the user app and are stored into 'scores by date-time' database table.

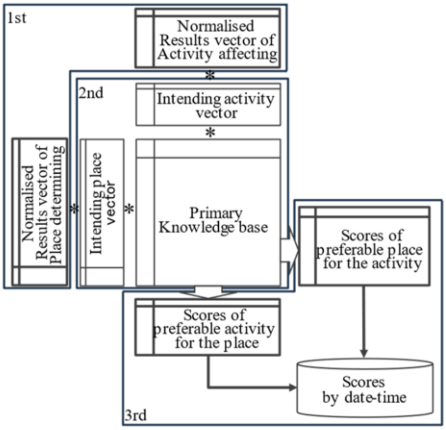


Figure 11. Primary knowledge base calculation

5. Experiments

Some experiments were conducted to check the functionality of the system. The experiment did not use actual weather forecast data and indoor climate date of actual sensors. Because the actual data is not much different in a short term, therefore, the experiment used provisional data to emphasise the functionality of especially memorising the changes in timeseries and effects of organisational context vectors.

5.1 Experimental knowledge bases

For the experiment, we defined the primary knowledge bases, as shown in **Table 3**, the complementary knowledge base as **Table 4-1, 4-2, 4-3, and 4-4**

Table 3. Primary Knowledge base; M: 'Activity and Place'

Activities / **Places**	Context type name	solo work; high concentration,	solo work; low concentration,	co-work	casual communication	formal communication
work from home	aac_ho	1.00	0.80	0.00	0.20	0.80
favourite 3rd place	aac_tp	0.60	0.60	0.00	0.00	0.00
a booth in the office	aac_co	0.80	0.20	0.00	0.00	0.00
an open desk in the office		0.60	0.80	0.60	0.40	0.20
open communication in the office		0.40	0.60	1.00	0.80	0.20
a meeting room in the office		0.00	0.00	0.20	0.40	1.00

Table 4-1. Complementary knowledge base; MA: Activity affecting - General (none place dependent)

Parameters	options \ Activities	Context type name	solo work; high concentration,	solo work; low concentration,	co-work	casual communication	formal communication
General (none place dependent)							
Job type	Administration	aac_gn	0.40	0.60	0.40	0.40	0.80
	Coordinator		0.40	0.60	0.60	0.40	1.00
	Business planning		1.00	0.80	0.80	1.00	0.40
	R&D		1.00	0.80	1.00	1.00	0.40
	Sales		0.60	1.00	0.60	0.80	0.60
psychological safety	very good	aac_gn	0.40	0.60	0.80	1.00	0.60
	good		0.40	0.60	0.60	0.80	0.60
	neutral		0.40	0.40	0.40	0.40	0.40
	bad		0.20	0.20	0.20	0.20	0.40
	very bad		0.20	0.20	0.20	0.00	0.20

Table 4-2. Complementary knowledge base; MA: Activity affecting - Home and 3rd place dependent

Parameters	options \ Activities	Context type name	solo work; high concentration,	solo work; low concentration,	co-work	casual communication	formal communication
Home dependent							
Circumstance at home	live alone	aac_ho	1.00	0.60	0.40	0.40	0.60
	live together own room		1.00	0.60	0.40	0.40	0.60
	live together no own room		0.20	0.40	0.40	0.40	0.20
3rd place dependent							
Favourite 3rd place	Share open office	aac_tp	0.60	0.60	0.20	0.40	0.20
	Rental box		1.00	0.40	0.40	0.40	0.80
	Cafe		0.60	0.60	0.20	0.20	0.20
	Library		0.80	0.40	0.00	0.00	0.00
	others		0.60	0.40	0.60	0.60	0.60
	none		0.00	0.00	0.00	0.00	0.00

Table 4-3. Complementary knowledge base; MA: Activity affecting - Centre office dependent

Parameters	options \ Activities	Context type name	solo work; high concentration,	solo work; low concentration,	co-work	casual communication	formal communication
Centre office dependent							
refreshment	drink	aac_co	0.60	0.80	0.60	1.00	0.20
	snack		0.40	0.40	0.40	1.00	0.00
	meal		0.40	0.40	0.40	0.80	0.00
attendances	preferable people	aac_co	0.40	0.80	0.80	1.00	0.60
	not dislike people	aac_co	0.00	0.60	0.40	1.00	0.20
temperature	22°C to 24°C	aac_co	0.80	0.80	0.60	0.80	0.40
	24°C to 26°C		0.80	0.80	0.60	0.80	0.40
	26°C to 28°C		0.80	0.80	0.60	0.80	0.40
humidity	35% to 45%	aac_co	0.80	0.80	0.60	0.80	0.40
	45% to 55%		0.80	0.80	0.60	0.80	0.40
	55% to 65%		0.80	0.80	0.60	0.80	0.40
CO2	(1-(ppm-1000)/1500)	aac_co	1.00	0.80	0.60	0.60	0.60
illuminance	Less 300Lx	aac_co	0.20	0.20	0.20	0.60	0.00
	300-600Lx		0.80	0.80	0.60	0.80	0.80
	Over 600Lx		0.20	0.20	0.40	0.20	0.60

Table 4-4. Complementary knowledge base; MP: Place determining

Parameters	options \ Places	Context type name	work from home	favourite 3rd place	a booth in the office	an open desk in the office	open communication in the office	a meeting room in the office
Location of the centre office	Very like	pdc_gn	0.20	0.20	1.00	1.00	1.00	1.00
	like		0.60	0.40	0.80	0.80	0.80	0.80
	neutral		0.80	0.60	0.60	0.60	0.60	0.60
	dislike		1.00	0.80	0.40	0.40	0.40	0.40
	Very dislike		1.00	1.00	0.60	0.60	0.60	0.60
Commuting time	In 30-mins	pdc_gn	0.40	0.00	0.80	0.80	0.80	0.60
	30 - 60 mins		0.60	0.20	0.60	0.40	0.60	0.20
	60-120 mins		0.80	0.40	0.20	0.40	0.60	0.20
	Over 120 min		1.00	0.60	0.00	0.20	0.40	0.00
Probability Of Precipitation	0%	pdc_gn	0.40	0.40	0.50	0.50	0.50	0.50
	10%-40%		0.40	0.40	0.50	0.50	0.50	0.50
	50%		0.60	0.40	0.50	0.50	0.50	0.50
	60%-90%		0.80	0.20	0.25	0.25	0.25	0.25
	100%		1.00	0.20	0.00	0.00	0.00	0.00

The classification of indoor quality, such as temperature; 22℃ to 24℃, of centre office was set by the authors' experience base on Japanese legislation: 'Act on Maintenance of Sanitation in Buildings' [8].

5.2 Organisational context vectors

We prepared two organisational context vectors (ocv), as shown in **Table 5-1, 5-2, 5-3** and **5-4**. One of it, id is set as '0', the sub totals of weight of each context type (cx_type) are same each other. It means the 'general (none place dependent) context is occupied half of the total weight. On the other hand, the other, id is set as '1', weighs more on place dependent contexts, and this weight setting is expected to result more diverse.

Table 5-1. Organisational context vector (ocv) for activity affecting context(aac) - General (none place dependent)

			Organisational context vector (ocv)					
		Context type name	id=0			id=1		
Parameters			sub total per parameter	sub total per cx_type	acc_gn +acc_xx	sub total per parameter	sub total per cx_type	acc_gn +acc_xx
General (none place dependent)								
Job type	Administration	aac_gn	25%	50%	-	10%	20%	-
	Coordinator							
	Business planning							
	R&D							
	Sales							
psychological safety	very good	aac_gn	25%			10%		
	good							
	neutral							
	bad							
	very bad							

Table 5-2. Organisational context vector (ocv) for activity affecting context(aac) - Home and 3rd place dependent

			Organisational context vector (ocv)					
		Context type name	id=0			id=1		
Parameters			sub total per parameter	sub total per cx_type	acc_gn +acc_xx	sub total per parameter	sub total per cx_type	acc_gn +acc_xx
home dependent								
Circumstance at home	live alone	aac_ho	50%	50%	100%	80%	80%	100%
	live together own room							
	live together no own room							
3rd place dependent								
Favourite 3rd place	Share open office	aac_tp	50%	50%	100%	80%	80%	100%
	Rental box							
	Cafe							
	Library							
	others							
	none							

Table 5-3. Organisational context vector (ocv) for activity affecting context(aac) - Centre office dependent

			Organisational context vector (ocv)					
		Context type name	id=0			id=1		
Parameters			sub total per parameter	sub total per cx_type	acc_gn +acc_xx	sub total per parameter	sub total per cx_type	acc_gn +acc_xx
Centre office dependent								
refreshment	drink	aac_co	(50/9)%	50%	100%	(80/9)%	80%	100%
	snack		(50/9)%			(80/9)%		
	meal		(50/9)%			(80/9)%		
attendances	preferable people	aac_co	(50/9)%			(80/9)%		
	not dislike people	aac_co	(50/9)%			(80/9)%		
temperature	22°C to 24°C	aac_co	(50/9)%			(80/9)%		
	24°C to 26°C							
	26°C to 28°C							
humidity	35% to 45%	aac_co	(50/9)%			(80/9)%		
	45% to 55%							
	55% to 65%							
CO2	(1-(ppm-1000)/1500)	aac_co	(50/9)%			(80/9)%		
illuminance	Less 300Lx	aac_co	(50/9)%			(80/9)%		
	300-600Lx							
	Over 600Lx							

Table 5-4. Organisational context vector (ocv) for Place determining context (pdc)

Parameters		Context type name	Organisational context vector (ocv) id=0 sub total per parameter	id=0 sub total per cx_type	id=0 pdctotal	id=1 sub total per parameter	id=1 sub total per cx_type	id=1 pdc total
General (none Activity dependent)								
Location of the centre office	Very like	pdc_gn	(100/3)%	100%	100%	30%	100%	100%
	like							
	neutral							
	dislike							
	Very dislike							
Commuting time	In 30-mins	pdc_gn	(100/3)%			30%		
	30 - 60 mins							
	60-120 mins							
	Over 120 min							
Probability Of Precipitation	0%	pdc_gn	(100/3)%			40%		
	10%-40%							
	50%							
	60-90%							
	100%							

5.3 Conducted experiments

we prepared, to check the functionality of the prototype system, the following 3-year scenario (data) as shown in **Table 8**. Most of the contexts were same. Indoor temperature, humidity, and probability of precipitation (pop) vary from season to season, but the values are the same on the same days each year.

There were two changes in timeseries. At first, there was only drink as refreshments at the centre office. The 2nd year, the organisation started to provide snack and meal to attract the employees. In the 3rd year, no contexts were changed except the personal contexts vector (pcv) of the user for refreshments. The user had not been very impressed with the refreshment at first, but after two years realised its importance.

For the scenario, we applied two organisational context vectors (ocv) as shown in previous section. With the organisational context vector of id=0, the weight of general (none place dependent) activity affecting context (aac_gn) and place dependent activity affecting contexts (aac_ho, aac _tp or aac_co) are equal (50% each). Since aac_gn contexts are static, the results were expected not much to differ from each other. With the other ocv of id=1, it weighs more toward dynamic contexts, therefore the results were expected to be mote variable.

5.4 Experiment results

As shown in **Figure 12,** when the refreshment setting was changed on 2025-01-01, the no 1 ranked place was changed to booth of centre office from work from home. Not soon after the personal context vector (pcv) was change, however, on 2026-07-01, the no 3 and no 4 ranked places are switched each other. Thus, the system can show the change in timeseries according to the contexts of both complementary and personal contexts.

As shown in **Figure 13**, completely different results were shown if the organisational context vectors (ocv) were different. With ocv of id=1, the appropriate ranks were more variable than the results with ocv of id=0. With ocv of id=1, the contexts change scenario did not much affect the results. However, on 2026-01-01 soon after the pcv had been changed, the no1 ranked place was changed from the same day in previous year. At this timing, the results with ocv of id=0 was not changed. Therefore, different ocv can bring different changes in timeseries.

Table 6. Experimental scenario

		2024/1/1 AM	2024/4/1 AM	2024/7/1 AM	2024/10/1 AM	2025/1/1 AM	2025/4/1 AM	2025/7/1 AM	2025/10/1 AM	2026/1/1 AM	2026/4/1 AM	2026/7/1 AM	2026/10/1 AM
Intending Activity		solo high concentrate				←				←			
job type		planning 100%				←				←			
Psychological safety		soso				←				←			
Circumstance home		Live together no own room				←				←			
Favorite 3rd place		Rental booth				←				←			
Attendance	Preferable people	Yes there (1)				←				←			
	Dislike people	Yes there (0)				←				←			
Indoor	temperature	20°C	24°C	29°C	25°C	20°C	24°C	29°C	25°C	20°C	24°C	29°C	25°C
quality	humidity	20%	50%	60%	40%	20%	50%	60%	40%	20%	50%	60%	40%
	CO2 density	1500ppm				←				←			
	illuminance	500lx				←				←			
Centre office Area		like				←				←			
Commuting time		50 mins				←				←			
POP		0%	30%	100%	50%	0%	30%	100%	50%	0%	30%	100%	50%
Variable data													
refreshment	drink	1	1	1	1	1	1	1	1	1	1	1	1
	snack	0	0	0	0	**1**	**1**	**1**	**1**	1	1	1	1
	meal	0	0	0	0	**1**	**1**	**1**	**1**	1	1	1	1
pcv	all refreshments	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	1	1	1

Refreshment settings are changed

pcv are changed

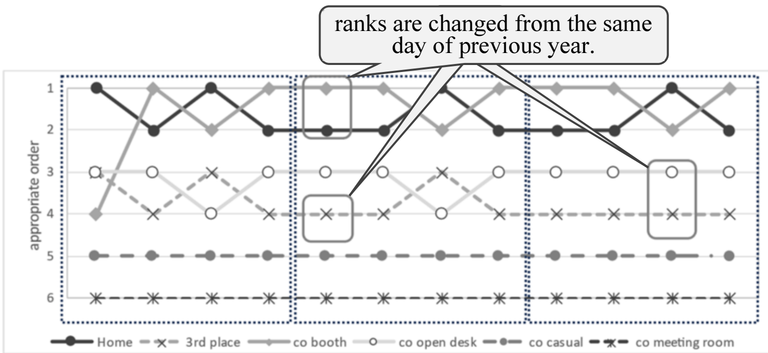


Figure 12. Appropriate place (ocv id= 0)

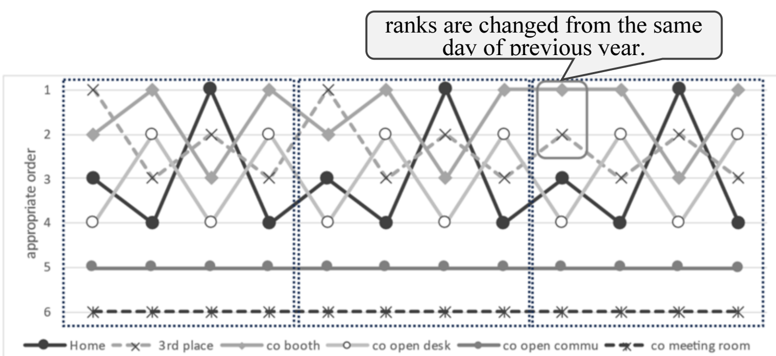


Figure 13. Appropriate place (ocv id= 1)

6. Conclusions and Future Work

Herein, the prototype system, implemented in this paper, could not only calculate tri-knowledge base model proposed in previous study [1], but also could memorise the changes in timeseries of workplaces. In addition, the organisational context vector, proposed in this paper, could bring different results, and it means that the knowledge bases are not necessary changed to adjust to certain organisations' preferences.

However, the system is still a study on the desk. To be a practical solution, the system must be applied in practice. When we will enhance this system for more complex simulation, we must prepare a data creator for multiple people's behaviours (intending activities or place to work). And the functionality must be evaluated as well as the contexts' adequacy, even more the knowledge bases.

The system will be used in an actual workplace of a company. In the future practice, we will add 'review' function to the system. There will be two purposes of the review function. One of them will be to evaluate the contexts and knowledge bases, and functionality of personal and organisational context vectors. Some self-adjustment function for the knowledge base and organisational context vectors will be also the target of the future research. Another purpose will be to investigate people's behaviours. Even if the system may offer proper recommendation, people may sometime not behave according to the recommendation. Many workplace planners know from experience that it takes time for people to understand the intention of a new workplace environment and behave appropriately. Therefore, the learning process of the workplace users must be simulated in the workplace digital twin which this research aims to establish in the future. Thus, the function to memorise changes in timeseries, which was implemented in this study, was important.

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