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Assessing Management Measures in Large-Scale Residential Facilities: An SNS-Driven Evaluative Approach

The University of Tokyo

Long Fu, Kazuhiro Aoyama

INCOSE International Symposium 2025 | Ottawa, Canada

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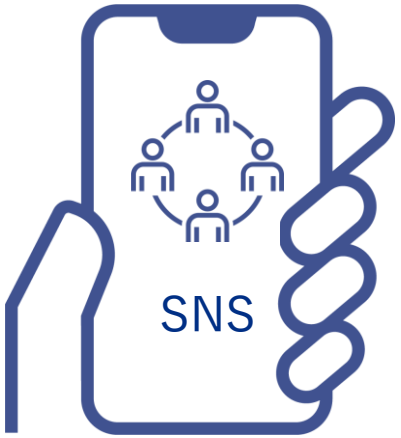
1.1 Research Background

- In **large scale residential facility**, various **management measures (events and services)** are implemented to improve residents' quality of life, satisfaction, community, and asset value. However:
  1. **Households' diverse needs and demands** make individual satisfaction hard to assess and evaluate.
  2. **Traditional survey lack comprehensive, quantitative evaluation.**
  3. **Real-time** impact of initiatives is difficult to observe.

Typical Large Scale Residential Facility in Japan

- Meanwhile, **resident-exclusive SNS** is increasingly adopted in large scale residential communities.
- As large volume of data is available become available anytime, **SNS data can offset traditional limitations of survey and offer valuable insights for large scale residential facility management.**



1.2 Research Goals & Objectives

Objective

By integrating traditional survey data and resident-exclusive SNS data, the study aims to build a systematic model that captures residents' dynamic and temporal needs of large-scale residential buildings, and enables data-driven, quantitative evaluation of management measures over time.

■ **Key goals to achieve are:**

1. **Systematic model which reflects the users, survey, and resident-exclusive SNS, as a base of research.**
2. **Categorize and understand residents in a temporal and continuous way.**
3. **Quantify the impact of measures, that allow community planners to compare and evaluate measures.**

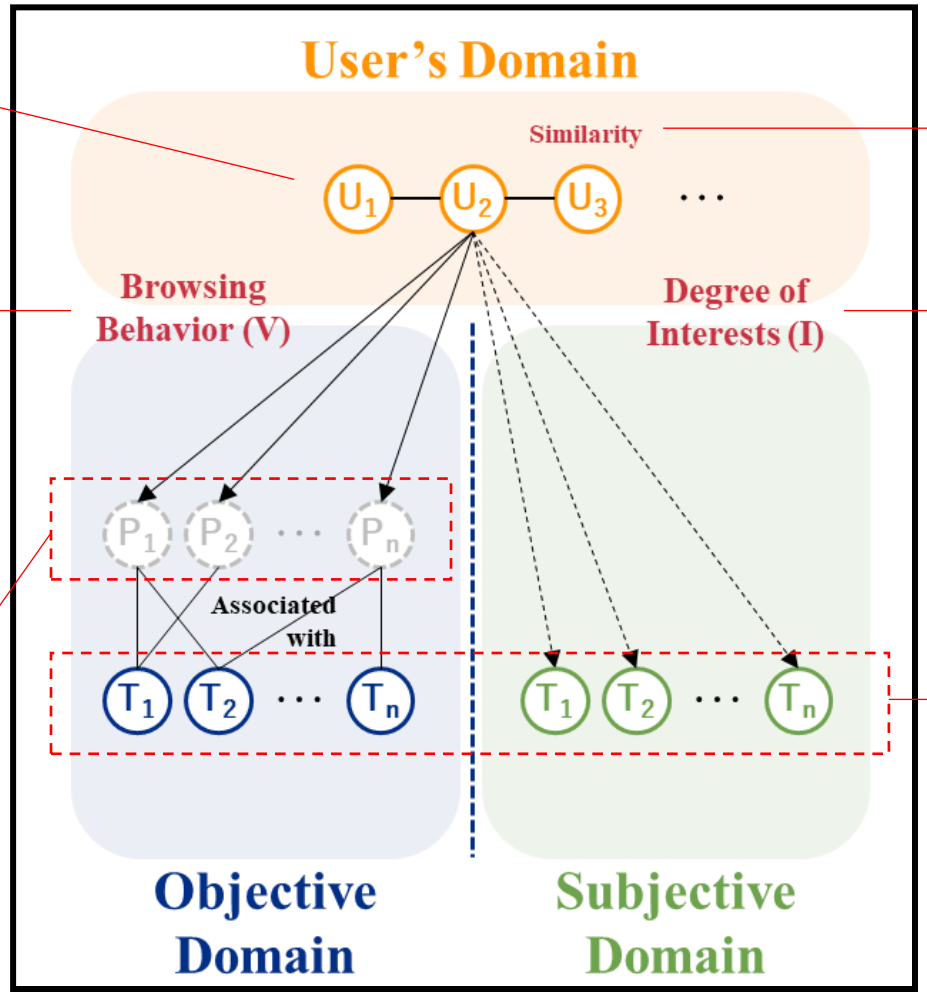
3.1 Base Structure for the Analysis

■ **To count for the relationship and systematic structure of 「Resident-SNS-Survey」, a 3-domain structure model 「User–Objective-Subjective」 is introduced to reflect elements within.**

User Node (G_U)
- Attributes: User' characteristics

Browsing Behavior ($G_U \rightarrow G_P$)
- Indicate number of times that a user browsed a post.
- Attributes: Browsing Counts, timestamp

Post Nodes (G_P)
- Post Entries written on resident-exclusive SNS.
- Attributes: Contents, timestamp



Users Similarity ($G_U \Leftrightarrow G_U$)
- Calculated based on behavior. Value between [0,1]

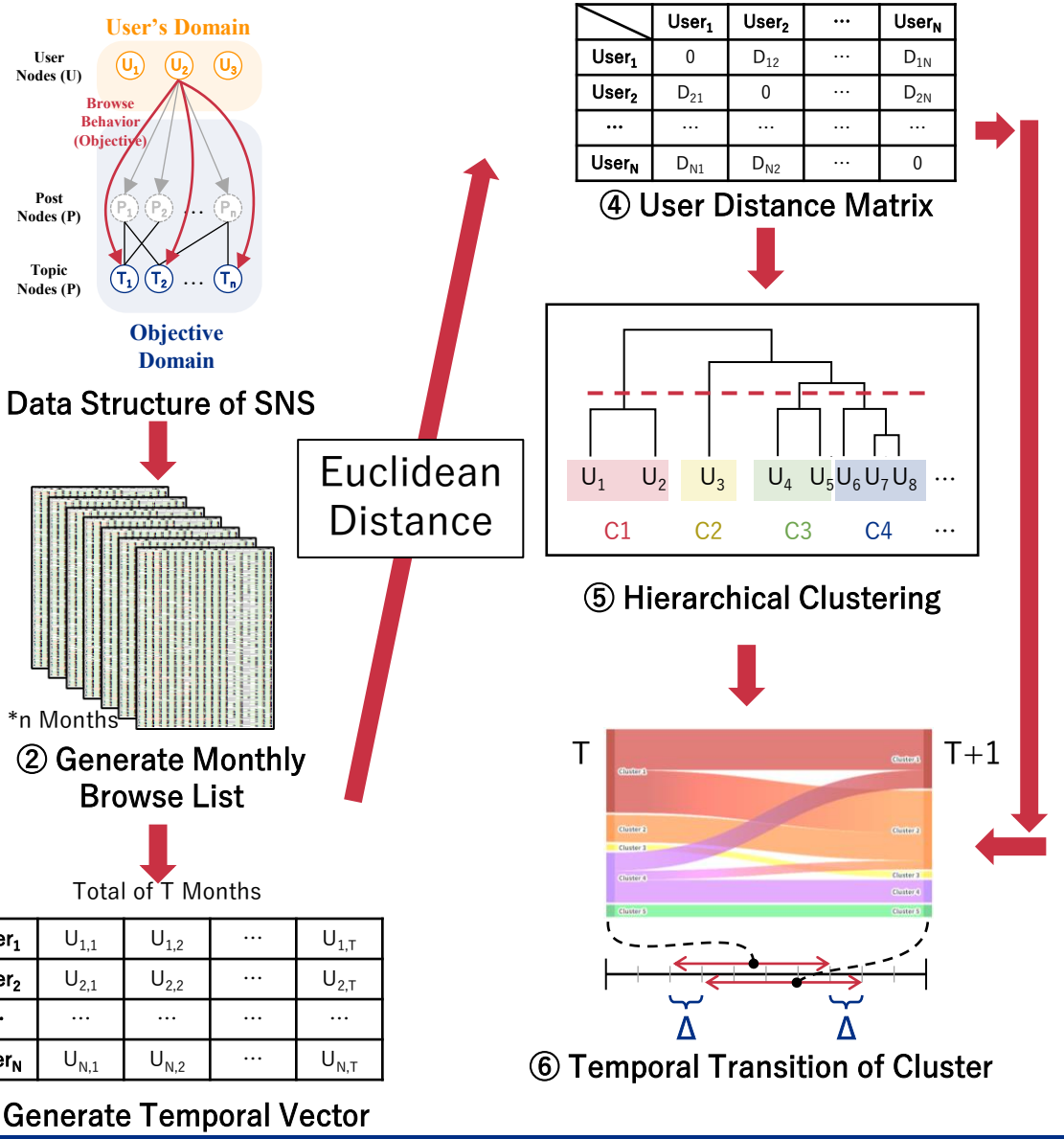
Degree of Interest ($G_U \rightarrow G_T$)
- Show users' subjective interest towards a particular topic.
- Attribute: Value between [0,1].

Topic Nodes (G_T)
- Topics that users are interested in, and included in SNS posts.

3.2 Clustering Based on Temporal Behavior

- Users were clustered based on temporal browsing behavior on a resident-exclusive SNS.
- Step ⑤ interprets these behavior-based clusters using survey data on values and interests.
  - ⇒ Examining correlations between behavior, values, and interests.
- Step ⑥ clusters users based on behavioral changes over time.
  - ⇒ Visualizing how user clusters evolve.

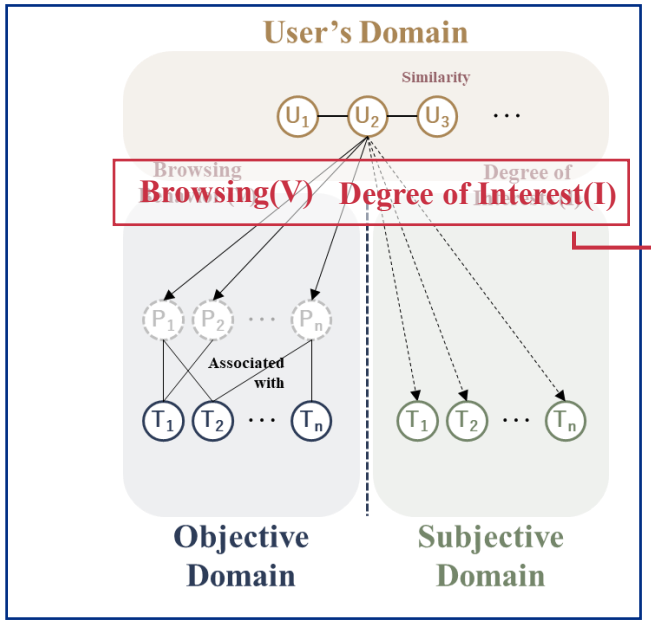
$$Euculidean\ Dist_{x,y} = \sqrt{\underbrace{\sum_{m=1}^{M}}_{\text{All Period}} \underbrace{\sum_{t=1}^{T}}_{\text{All Topics}} \left(x_{m,t} - y_{m,t}\right)^2}$$



3.3 Quantifying the Impact of Measures（1/2）

■ **The impact of a certain topic is measured by multiplying browsing counts and degree of interest.**

⇒ **After measures are implemented, posts about the measures will appear on SNS, where users will browse.**



$$Impact_{Topic} = \sum_{i=1}^{N} (Browsing\ Count_i * Degree\ of\ Interest_i)$$

Objective (SNS)

Subjective (Survey)

Issue 1

Some estimation is required since users' interest levels cannot be fully observed.

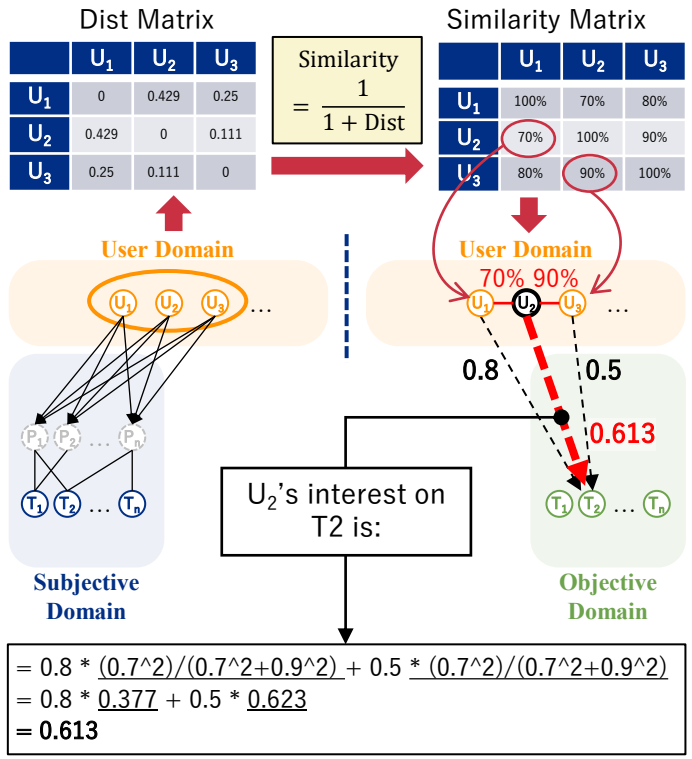
Issue 2

Usage frequency varies by user, so standardization is necessary.

Issue 3

There exist direct and indirect impact from measures.

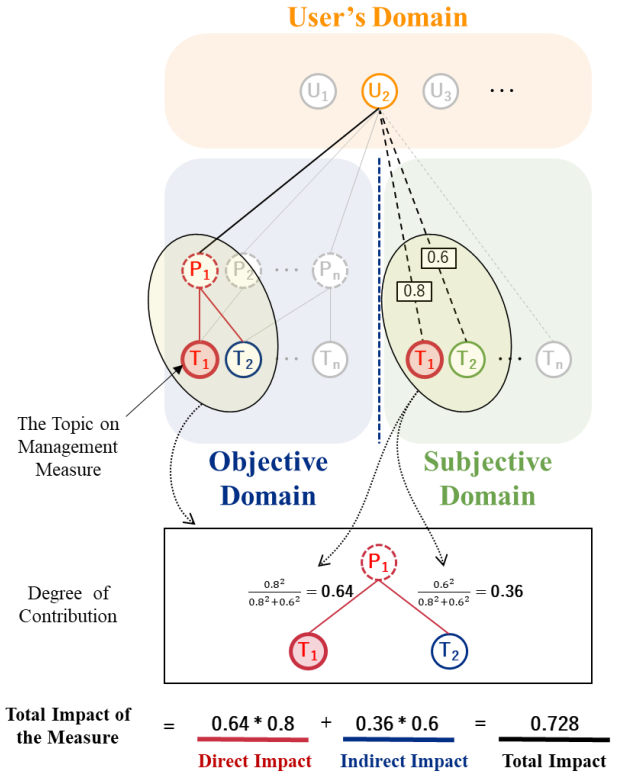
3.3 Quantifying the Impact of Measures（2/2）



	U_1	U_2	U_3
U_1	0	0.429	0.25
U_2	0.429	0	0.111
U_3	0.25	0.111	0

	U_1	U_2	U_3
U_1	100%	70%	80%
U_2	70%	100%	90%
U_3	80%	90%	100%

User Name	User A	User B
Degree of Interest on $Topic_t$	0.8	0.8
Browse Counts on $Topic_t$	100	10
Fulfillment of Interest per Browse	$\frac{0.8}{100} = 0.008$	$\frac{0.8}{10} = 0.08$



Solve 1

Estimate individual' unknown behavior using similar users within the same cluster.

Solve 2

Standardize based on the number of actions up to a certain point in time.

Solve 3

Infer interest distribution across topics from each user's overall interest level.

4.1 Overview of Collected Data

- **The data is collected from an existing large scale residential community in Tokyo area, where lives more than 800 households.**

Actual Large Scale Residential Community

SNS Data

Collection Period	November 11, 2022 to November 30, 2023 (~1 Year)
Data Type and Number of Entities	1. Users: 497 Person 2. Posts: 679 Entities 3. Comments: 569 Entities 4. Likes: 2228 Entities 5. Browses: 61011 Entities* (Note: Browse data between 2023 May 17th to 2023 May 25th is not recorded due to the missing of data)

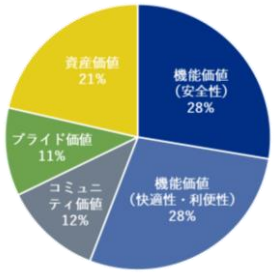
Survey Data

Collection Period	December 19, 2023 to December 31, 2023
Target Audience	164 relatively active residents registered within the year 2022. The survey was distributed via notifications on the SNS and by delivering to each dwelling.
Number of Valid Responses	**78** (Response Rate: 46.7%)
Survey Method	Online Survey (using Survey Monkey)
Survey Questions	1. **Basic Attributes**: Age, household composition, etc. 2. **Senses of Value Composition and Satisfaction**: Understanding residents' values in housing and their satisfaction levels. 3. **Subjective Evaluation**: Residents' personal opinions and assessments.

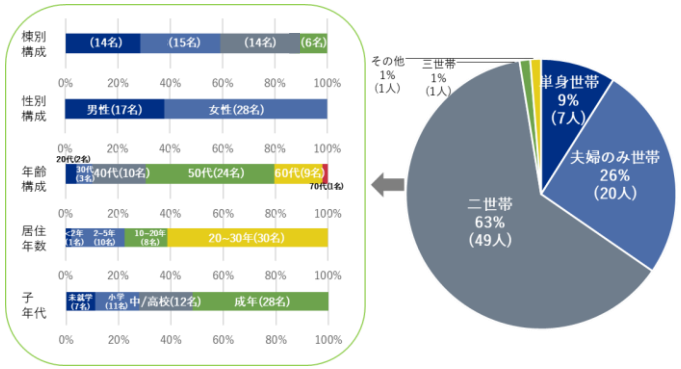
4.2 Quick Statistics of Data

■ **Meaningful information are available through statistical analysis.**

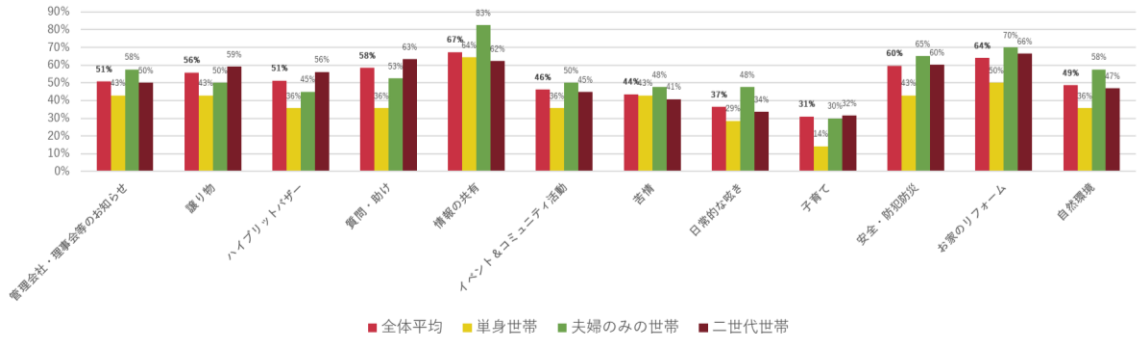
⇒ However, further assessments become possible by combining survey & time-series SNS data.



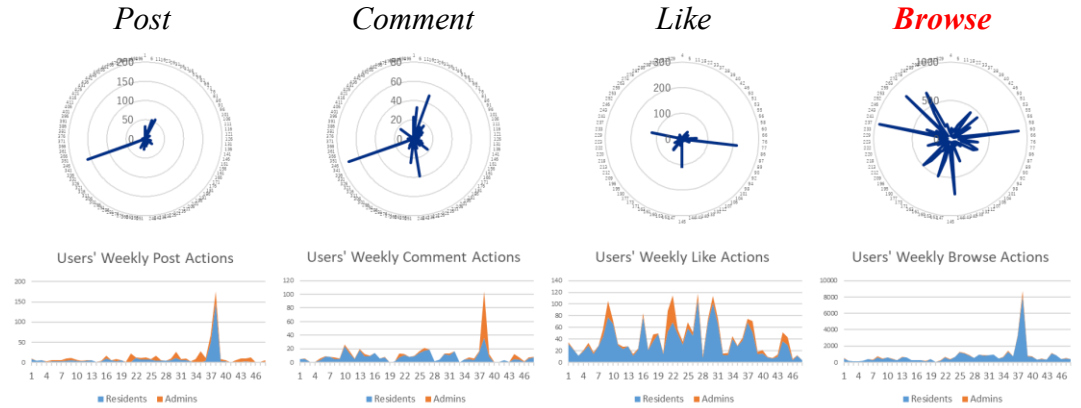
The Users' Average Proportion of Sense of Value (n=78)



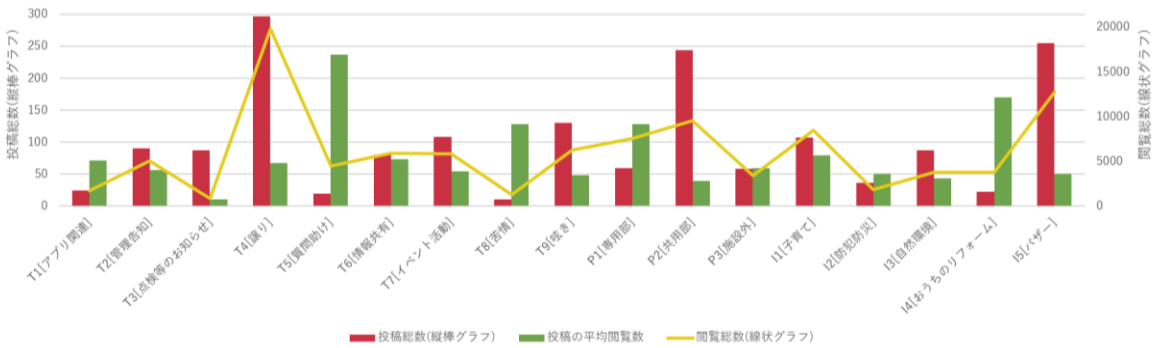
The Persona of Residents (n=78)



Users' Degree of Interests on the Topics on Resident-Exclusive SNS(n=78)



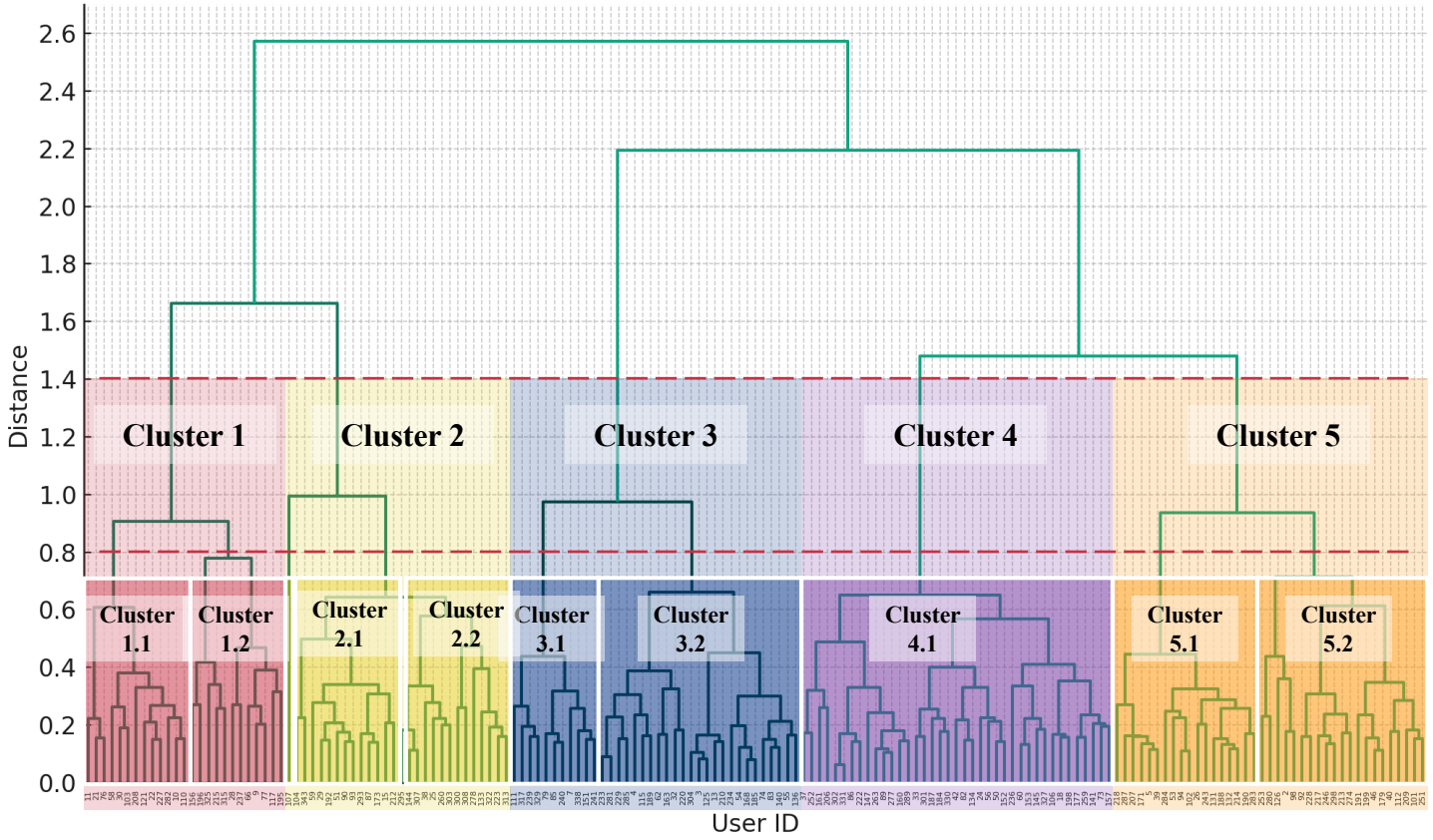
Variation in Posting, Commenting, Liking, and Browsing Actions (n=78)



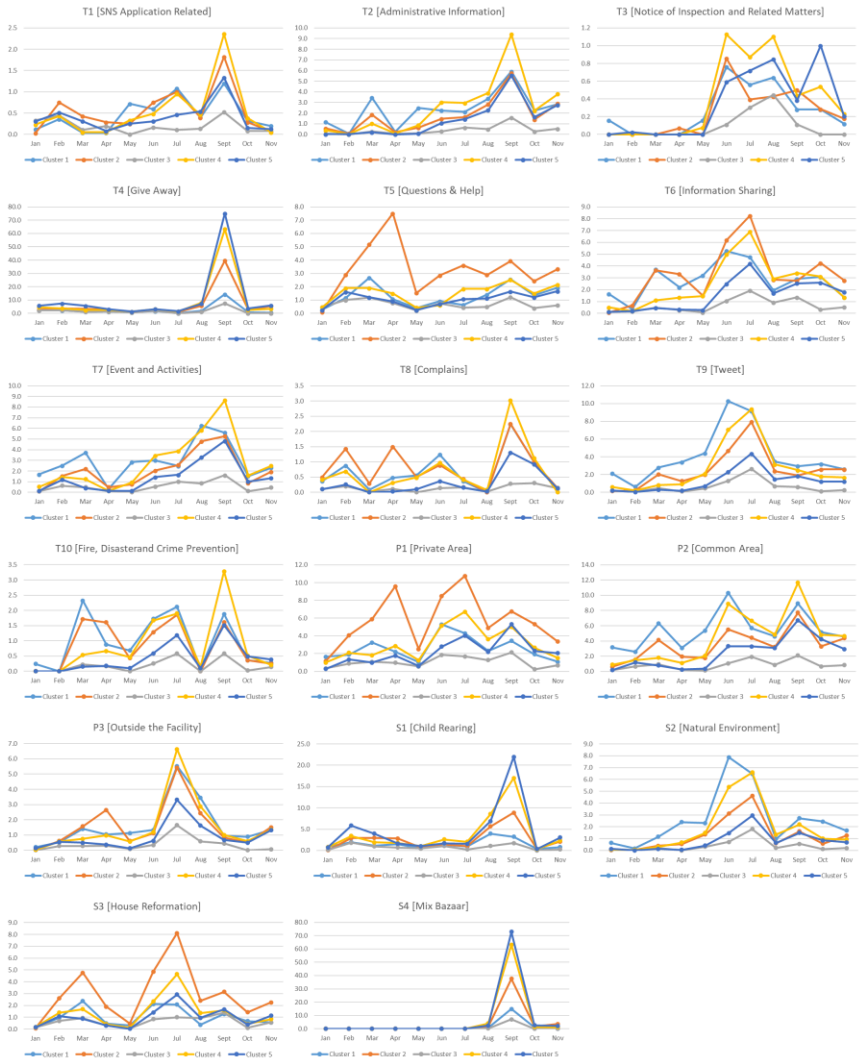
Statistics of Posting and Browsing on Each Topic

5.1 User Clustering（1/3）

- **Analysis**: Based on users' time-series browsing action, residents in the facility are concluded into 5 major clusters.
- **Discussion**: Users in same cluster show similarity based on their time-series browsing action.



Cluster Division Based on User's Browsing Behavior



Temporal Transition of Clusters Browsing Action on Topics

5.1 User Clustering (2/3)

- **Analysis**: Each cluster's attributes, mean and Relative Standard Deviation (RSD) are calculated to find relationships among residents' behavior, values, and interests.
- **Discussion**: Many features showed high variability despite low RSDs, showing the uniqueness of each cluster.
- **Conclusion**: Relatedness exists between users' browsing activities and potential interests. ⇒ Management can infer resident preferences by observing SNS activity.
- **Future Work**: Interview with residents is required to further proof he relatedness.

$$RSD_{i,m} = \left| \frac{Std.Dev._{i,m}}{Mean_{i,m}} \right| * 100\%$$

Legend

- Average. (RSD) : Each cell show average and RSD
- Whole users (Base of Comparison)
- : RSD lower than base
- Red Text : Average shifting more than 5% from the base

Cluster			% of Sense of Value					The Degree of Interest on each Topic											
Cluster	User No.	Survey Replies	Safety	Convenience & Confort	Community Value	Pride Value	Asset Value	T2 Admin Notification	T4 Give Away	T5 Questions & Help	T6 Info Sharing	T7 Event & Activities	T8 Complains	T9 Daily Chatter	T10 Crime and Disaster	S1 Child Rearing	S2 Natural Environment	S3 House Reform	S4 Mix Bazaar
Total	**167**	**78**	**27.6% (37%)**	**28.2% (29%)**	**12.0% (51%)**	**10.7% (47%)**	**21.4% (47%)**	**50.6% (49%)**	**55.8% (54%)**	**58.3% (47%)**	**67.3% (41%)**	**46.2% (67%)**	**43.6% (65%)**	**36.5% (79%)**	**59.6% (49%)**	**30.8% (115%)**	**48.7% (57%)**	**64.1% (52%)**	**51.3% (72%)**
Cluster 1	**25**	9	23.7% (50%)	26.2% (25%)	13.5% (68%)	11.4% (31%)	25.2% (52%)	61.1% (55%)	55.6% (54%)	61.1% (36%)	72.2% (36%)	50.0% (71%)	38.9% (86%)	44.4% (88%)	61.1% (36%)	16.7% (150%)	72.2% (50%)	72.2% (50%)	33.3% (75%)
Cluster 2	**28**	15	29.0% (37%)	30.0% (28%)	10.8% (41%)	11.3% (41%)	18.8% (31%)	46.7% (28%)	43.3% (74%)	56.7% (31%)	70.0% (36%)	43.3% (60%)	43.3% (41%)	40.0% (85%)	63.3% (47%)	20.0% (127%)	50.0% (38%)	76.7% (42%)	40.0% (85%)
Cluster 3	**36**	10	22.8% (36%)	29.6% (31%)	9.6% (54%)	11.8% (54%)	26.2% (48%)	50.0% (47%)	55.0% (52%)	55.0% (67%)	70.0% (37%)	25.0% (105%)	45.0% (82%)	30.0% (86%)	60.0% (53%)	15.0% (161%)	45.0% (63%)	70.0% (50%)	45.0% (63%)
Cluster 4	**39**	22	30.0% (34%)	29.5% (26%)	10.9% (42%)	11.0% (54%)	18.6% (46%)	50.0% (44%)	56.8% (49%)	54.5% (56%)	65.9% (49%)	52.3% (55%)	40.9% (61%)	34.1% (70%)	59.1% (56%)	50.0% (76%)	45.5% (58%)	61.4% (56%)	59.1% (72%)
Cluster 5	**39**	22	28.1% (35%)	25.9% (32%)	14.3% (47%)	9.3% (44%)	22.4% (46%)	50.0% (62%)	63.6% (50%)	63.6% (43%)	63.6% (43%)	50.0% (69%)	47.7% (68%)	36.4% (76%)	56.8% (49%)	31.8% (124%)	43.2% (65%)	52.3% (55%)	61.4% (61%)

Sense of Value and Degree of Interests' Average and RSD

The Whole Users : Base for comparison

Cluster 1 :High focus on asset and community value; strong interest in notices, casual posts, and natural environment.

Cluster 2 :Low focus on asset and community value; little interest in exchanges.

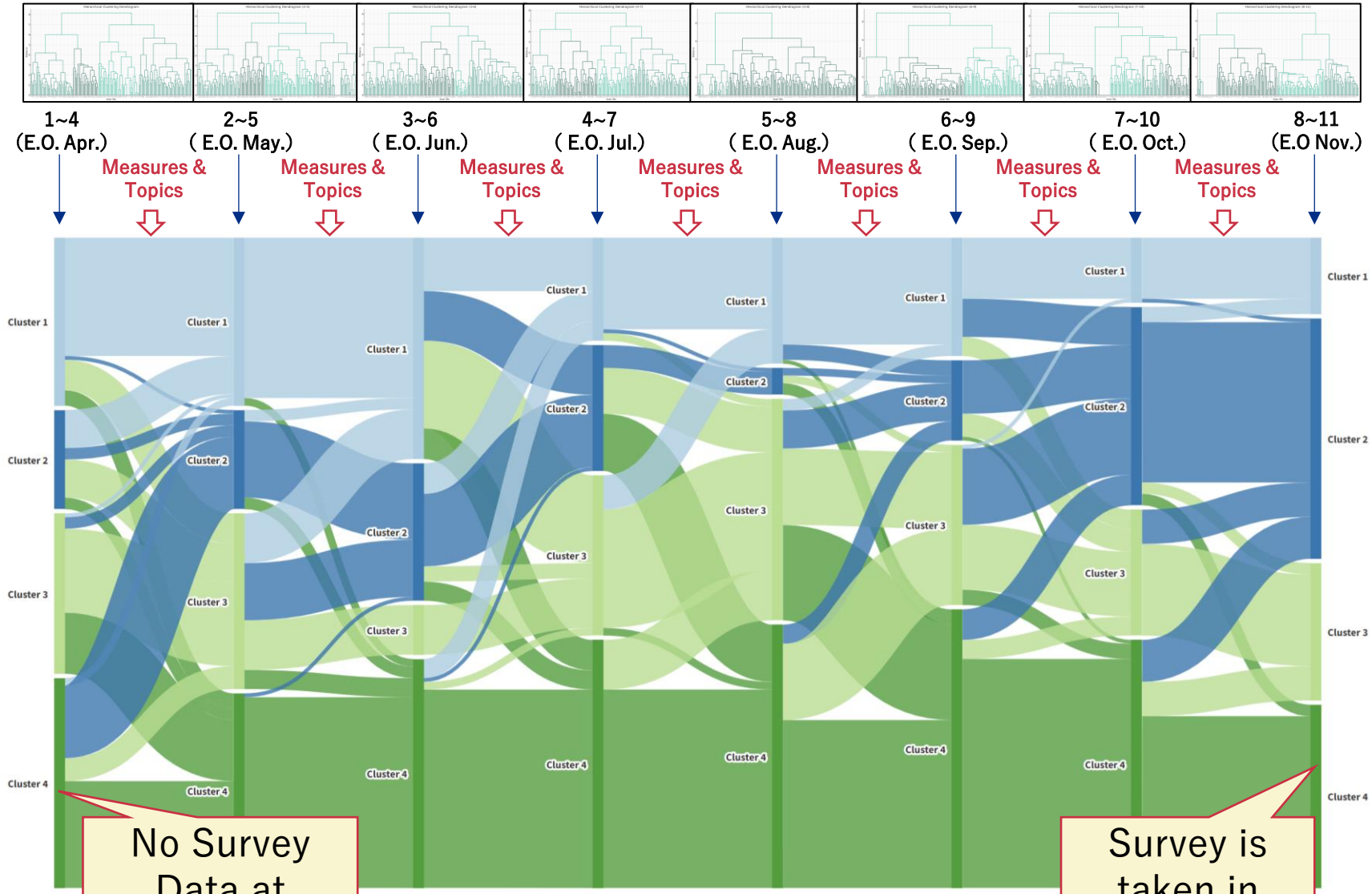
Cluster 3 :Low focus on safety and community; low engagement with events and posts; lowest view count; male-dominant.

Cluster 4 :Low focus on asset value; low interest in events and parenting.

Cluster 5 :High focus on community value; strong interest in item exchanges.

5.1 User Clustering (3/3)

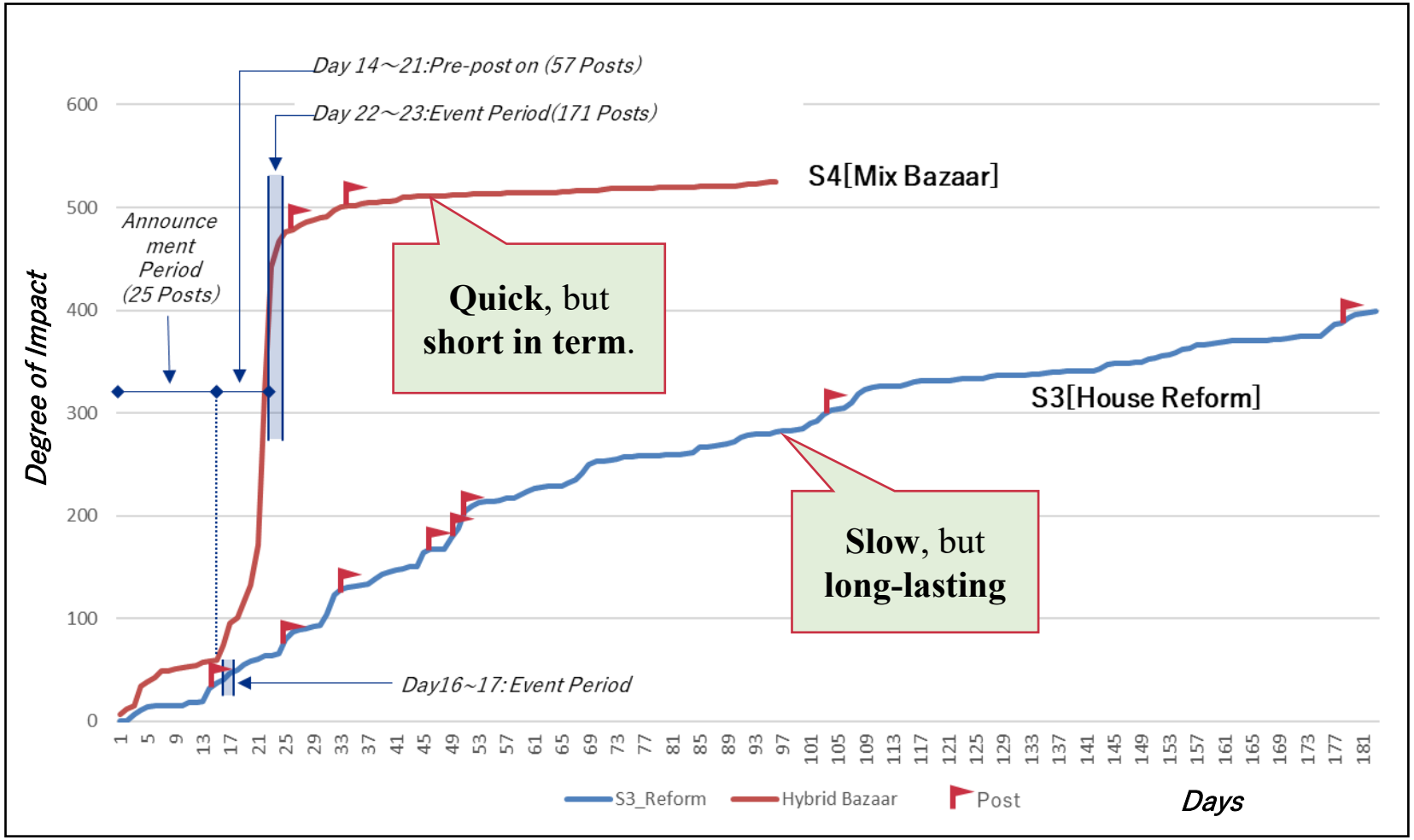
- **Analysis**: Clusters were calculated every 4-months.
- **Discussions**: Users' temporal transitions between clusters were observed. Which potentially reflect the effect of events and measures.
- **Implication**: Tracking the SNS data and users' cluster transition potentially offer real-time monitoring for the measures and events, and further "know the residents".
- **Limitation**: Lack of continuous survey to further proof such transition. Continuous survey shall be taken in future.



The Temporal Shifting of Users' Clustering

5.2 Quantitative Assessments of Measures （1/3）

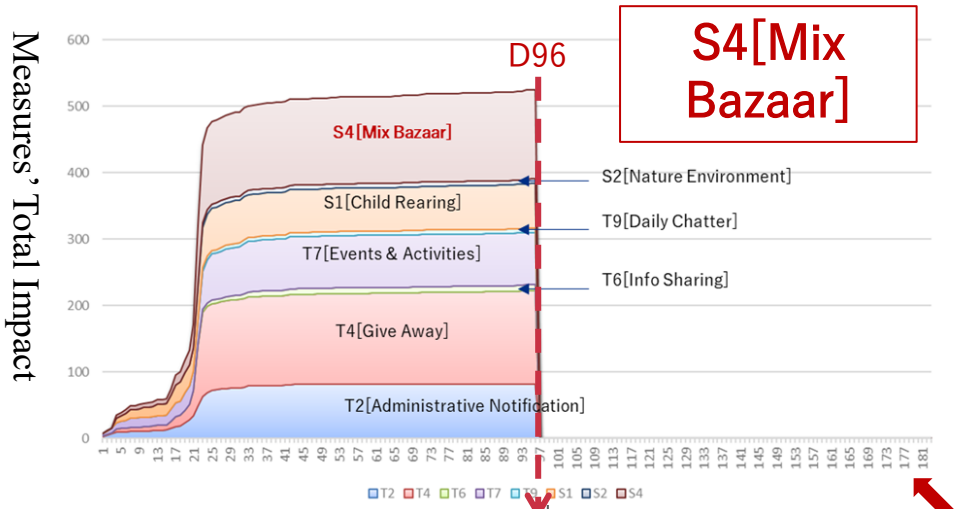
- **Analysis**: Two separate measures implemented, "Home Renovation" and "Mixed Bazaar", are compared by calculating their total impact.
- **Discussion**: The actual effect (degree of impact to) and tendencies of the become comparable between different measures.
- **Conclusion**: The research:
  - ①Enabled quantitative comparison of events and measures in large residential facilities.
  - ②Identified the temporal characteristics of each initiative's impact.

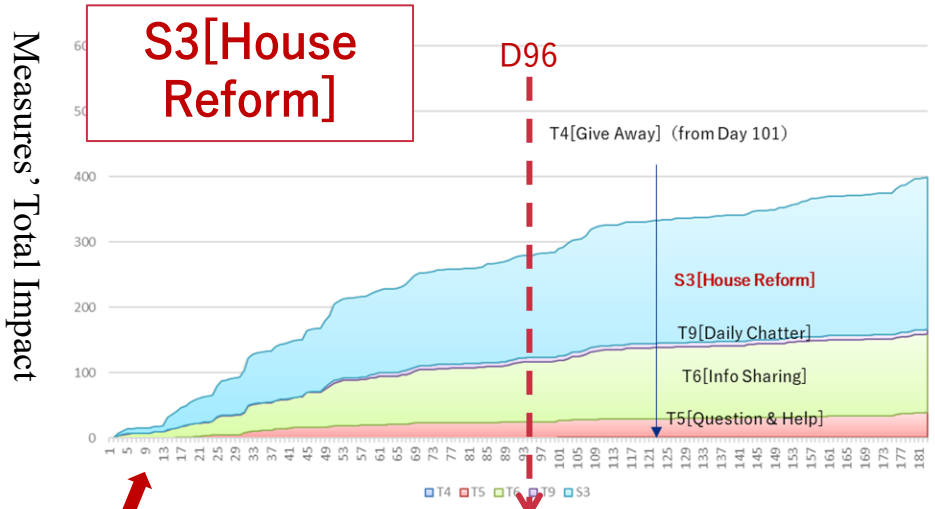


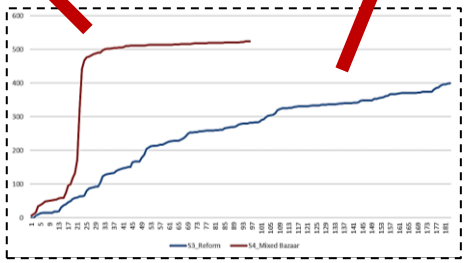
The Temporal Change of Measures' Degree of Impact

5.2 Quantitative Assessments of Measures （2/3）

- **Analysis: Separated total impact into topics and examined both direct and indirect effects based on Day 96.**
- **Findings: Direct effects were almost same for both measures. However, "Mixed Bazaar" had strong indirect effects from various topics, while "Home Renovation" showed high indirect impact through "Info Sharing."**
- **Conclusion: By distinguishing direct and indirect effects, secondary impacts of measures can now be identified and evaluated.**







Impact of S4 "Mixed Bazaar" (As of Day96)

$$= \text{Direct Imact} + \text{Indirect Impact}$$

$$= \sum Impact_{S4} + \sum Impact_{T2,T4,T6,T7,T9,S1,S2}$$

$$= 134.280 + 81.709 + 140.656 + 8.622 + 78.697 + 6.576 + 66.973 + 6.997$$

$$= 524.508$$

Impact of S3 "House Reform" (As of Day96)

$$= \text{Direct Imact} + \text{Indirect Impact}$$

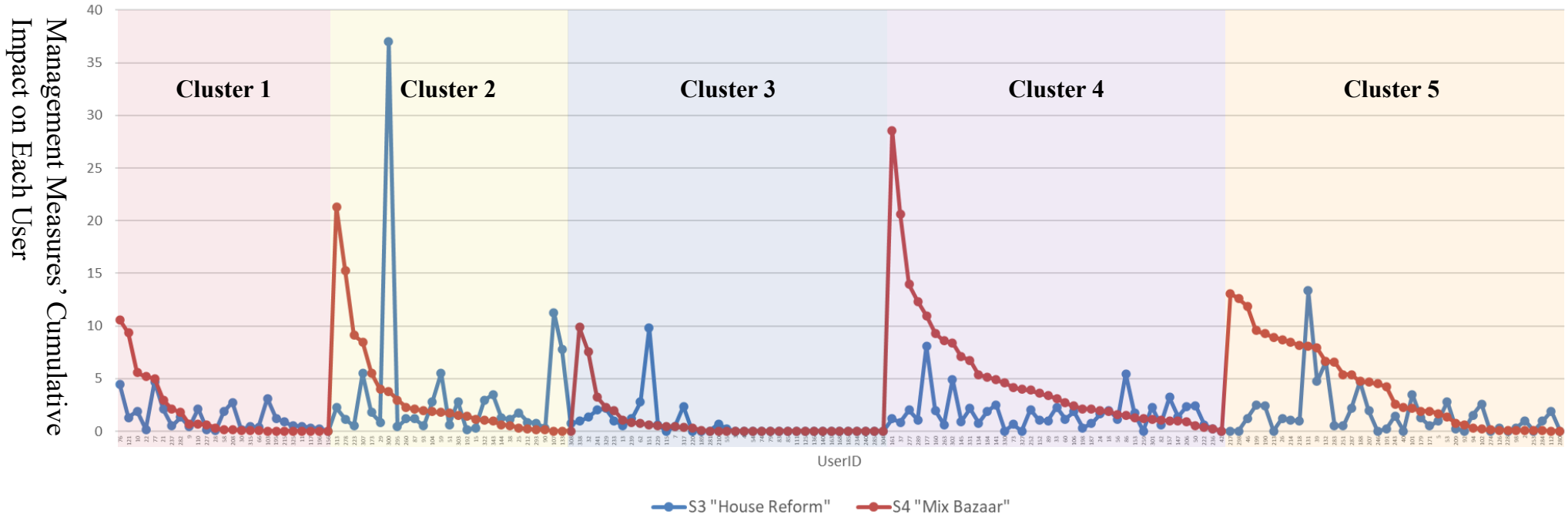
$$= \sum Impact_{S3} + \sum Impact_{T4,T5,T6,T9}$$

$$= 158.826 + 24.912 + 0 + 91.785 + 6.636$$

$$= 282.159$$

5.2 Quantitative Assessments of Measures （3/3）

- **Analysis**: Perceived benefit (interest fulfillment) from each measure are quantified based on user and cluster
- **Findings**:
  - "Mixed Bazaar" (red) showed a polarized distribution. "Home Renovation" (blue) had a more even spread around 0-5.
  - Clusters 1 and 3 had low benefit, while Clusters 2 and 4 showed the highest.
- **Conclusion**: Measures impact can be evaluated per user or cluster.
  ⇒ Enabling discussion on which user segments were most effectively engaged.



6.1 Conclusion

- This study integrated survey data with resident-exclusive SNS to quantitatively evaluate the effectiveness of management initiatives in large-scale residential facilities and to observe temporal changes. Key outcomes are:
  - ① Modeled the value realization structure of the SNS by with 「User – Objective -Subjective」 3 –domain model.
  - ② Identifying correlations between user behavior and both values and interests through time-series clustering.
  - ③ Quantitatively assessing initiative effects, distinguishing between direct and indirect impacts, temporal variations, and cluster-specific characteristics.
- Future work will focus on evaluating initiative effects through user state transitions and dynamic system modeling.

Objective

By integrating traditional survey data and resident-exclusive SNS data,
the study aims to build a systematic model that captures residents'
dynamic needs of large-scale residential buildings,
and enables data-driven, quantitative evaluation of management measures over time.

References

A. Kobayashi, C. Goto, Y. Shin, K. Yabuki, Y. Yoshimura and H. Koizumi. (2022). The Role of Local SNS in Community Interaction in a High-Rise Apartment District, Journal of the City Planning Institute of Japan, vol. 57, no. 3, pp. 698-704 (in Japanese)

Connect Platform Inc. (2022). GOKINJO: Creating Just the Right Connection Between People, Asahi Kasei Homes Corporation, 7.10.2022. [https://gokinjo.conepla.co.jp]. (in Japanese)

H. Sato. (2020). A Method for Describing Aging Superiority Using Value, Function, and Structure Models and Development of a Simulation Model: A Case Study of Sun City, University of Tokyo Graduate Thesis. (in Japanese)

H. Sato. (2023). Construction of a Value Evaluation Model and Simulation Based on the Actual Use of Common Areas in Large-Scale Residential Facilities, University of Tokyo Master Thesis. (in Japanese)

J. Nielsen. (2006). The 90-9-1 Rule for Participation Inequality in Social Media and Online Communities, Nielsen Norman Group, 8.10.2006.

[https://www.nngroup.com/articles/participation-inequality/].

M. Wada. (2021). Construction of Evaluation Metrics for Policies Aimed at Long-Term Superiority and Modeling of Interactions in Apartment Residents' Activities, University of Tokyo Graduate Thesis. (in Japanese)

Ministry of Land, Infrastructure, Transport and Tourism. (2023a) .Transition of Condominium Stock Numbers in Japan, 10.8.2023. [https://www.mlit.go.jp/jutakukentiku/house/content/001625310.pdf] (in Japanese)

Ministry of Land, Infrastructure, Transport and Tourism. (2023b). Trend in the Number of Condominium Stocks Over 40 Years Old in Japan (As of the End of 2022), 8.10.2022. [https://www.mlit.go.jp/jutakukentiku/house/content/001623967.pdf] (in Japanese)

S. Dhelim, N. Aung and H. Ning. (2020). Mining user interest based on personality-aware hybrid filtering, Knowledge-Based Systems, vol. 206, no. 28

S. Shibuya. (2017). Communication with Unknown Others-The Role of Interest Graphs in Offline and Online Contexts, Japan Marketing Journal, vol. 36, no. 3, pp. 23-36 (in Japanese)

S. Tsugawa. (2020). Utilization of Information Accumulated on Social Networking Services (SNS), IEICE communications society magazine, vol. 52, pp. 282-288

Y. Asami and J. Choi. (2004). A Study of The Relation Between Sense of Values and Residential Evaluation, Architectural Institute of Japan, vol. 576, pp. 133-139

Y. Kawabata, N. Ikebata, S. Nakao and S. Fujii. (2018). A Study on the Practical Methods of Smooth Consensus Building for Residential Communities of Condominiums, Policy and practice studies, vol. 4, no. 1, pp. 111-124

Y. Yamaguchi, S. Yamamoto and T. Sato. (2013). Clustering of Users Focused on the Transition of Posting Activities in Microblogs, Web Intelligence and Interaction, vol. 3