

A Method for Emerging Innovation and DX by Using P2P and Go

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Abstract—In 1995, a research project started at the NTT Laboratories with the goal of fostering innovation (creating new value through innovative ideas) and promoting DX (digital transformation of society, business, and organizations) through the “loosely connected and autonomous networks” of computers. This became known as “the Brokerless Theory,” the world’s first P2P (Peer-to-Peer) theory, which attracted global attention. From this new concept of “loosely connected and autonomous networks,” numerous innovative social models, business models, and internet services emerged, including Skype (Sky P2P), social networking services, blockchain. Recent research has revealed that a new concept called “the External Vector” is effective for fostering innovation and DX. The External Vector refers to building new, weak, loose, and autonomous connections between different fields, from which new value can be created. Along with technological innovation, which creates new value frameworks as technology advances, the External Vector serves as one of the two essential driving forces behind the emergence of innovation and DX.

This paper proposes the following three points:

- 1) The External Vector is effective for fostering regional innovation and regional DX.
- 2) Building connections using the External Vector requires verbalizing (theorizing) the essence of connections and training in the practical use of the verbalized concept.
- 3) The combination of “P2P Concepts and Principles” and “Go Concepts and Principles” is effective for verbalizing (theorizing) and training.

Furthermore, the effectiveness of combining P2P and Go is quantitatively demonstrated through a questionnaire survey conducted with 486 participants.

Keyword—P2P Theory, Go, Innovation, DX, External Vector

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I. INTRODUCTION

SOME problems such as depopulation in rural areas and financial difficulties caused by a declining birthrate, aging population, and urban concentration are accelerating the decline and depopulation of local regions in Japan. In such a situation, we have to promote regional innovation and regional DX, that is, the creation of new values and the transformation of society, business, and organizations in local regions as soon as possible in order to revitalize those local regions.

Therefore, this paper proposes the following methods for fostering regional innovation and regional DX in the context of regional revitalization [1], [2] (see Fig. 1).

- 1) In regional innovation and regional DX, the External Vector (building new, weak, loose, and autonomous connections across different fields) is effective in creating new values rather than relying on strong connections (the Internal Vector), which have been considered common sense until now. By connecting regional resources through the External Vector, new values are created from these connections. In other words, the External Vector is effective in generating innovation from connecting regional resources from different fields. At the same time, a shift in thinking from the Internal Vector to the External Vector is necessary, and it is important to balance the use of both the Internal and External Vectors.
- 2) Building connections through the External Vector requires verbalizing (theorizing) the essence of connections.
- 3) Training to build connections through the External Vector, in other words, fostering an awareness of loose connections, is required. It is not easy to acquire awareness to connect weakly and loosely because we usually and unconsciously try to connect strongly. Therefore, training to practically utilize the concept of the External Vector is necessary.
- 4) It is effective to combine the concepts and principles of P2P and Go as a theory and training on how to generate regional innovation and regional DX, that is, how to build connections among regional resources through the External Vector. Go, a board game, and P2P, a network theory, have a high degree of similarity as shown in Table 1, so synergistic effects can be obtained by combining the two.

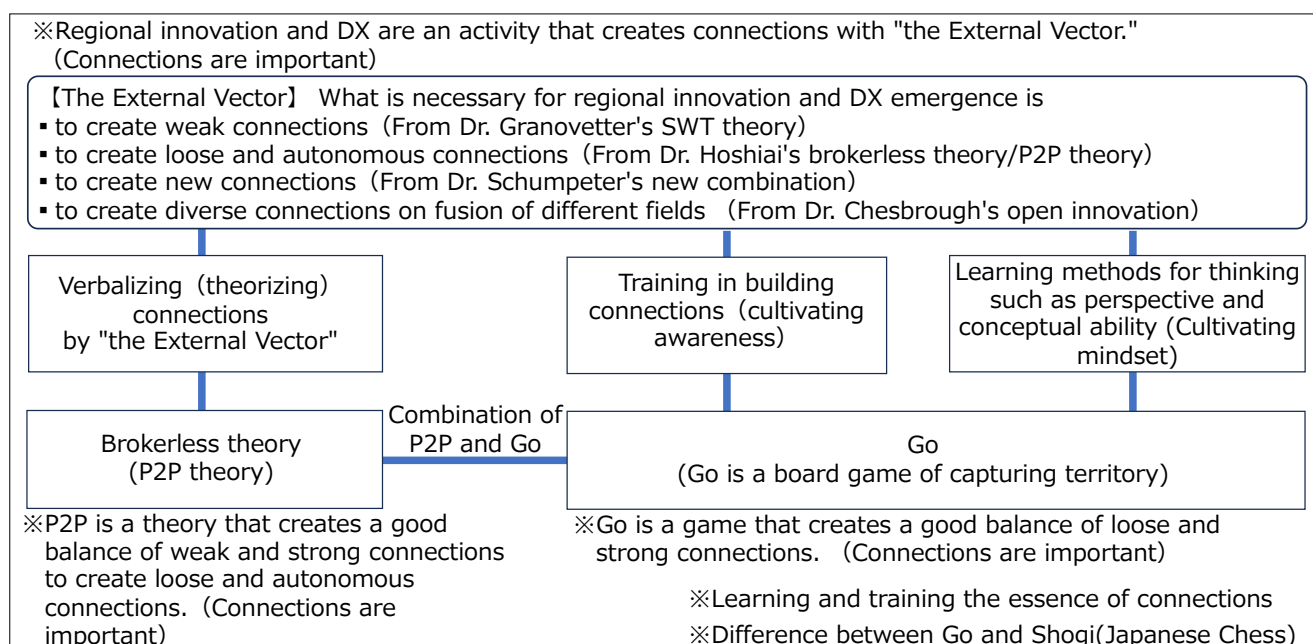


Fig. 1. Proposed method for regional innovation and DX emergence (a connection-building method using the External Vector).

Furthermore, an empirical study of 486 participants clarifies the effectiveness of combining P2P and Go.

II. EFFECTIVENESS OF THE EXTERNAL VECTOR

This chapter verifies the effectiveness of the External Vector (building new, weak, and loose connections across different fields) for fostering regional innovation and regional DX through a comparison with conventional studies.

A. Weak connections

Reference [3] pointed out from a sociological perspective that new values do not emerge from those connected by strong connections, such as family, close friends, coworkers, or groups with clear and shared goals and empathy. This means that new values are unlikely to emerge from internal planning meetings or within single industries or fields that share common values. Such connections, which were defined as "strong ties" in [3], are called "strong connections" or "the Internal Vector" in this paper. In short, it is difficult to create new values from strong connections.

On the other hand, it is more likely that new value will be created when social connections are weaker, such as friends of friends, casual acquaintances whose age, occupation, or address are unknown, acquaintances of acquaintances, and mom friends who meet occasionally. These connections defined as "weak ties" in [3] are referred to as "weak connections" in this paper.

For example, according to [4], 33% of employees in the U.S. are enthusiastic about working, while in Japan the figure is the lowest at 5%, or about a seventh of the U.S. level. Therefore, the percentage of employees who are willing to learn (reskilling) is also overwhelmingly low in Japan, at a third of that in the U.S. As a result, a vicious cycle in which wages do not increase has developed in Japan. This is due to the fact that most Japanese companies adopt a membership-based employment system. In a membership-based employment system, companies and

employees are connected through strong connections akin to a parent-child relationship, which fosters strong conformity and a tendency to maintain the status quo. In contrast, in the United States, a job-type employment system is widely adopted. In this system, companies and employees maintain an equal relationship and are connected through weak connections, which fosters a high willingness to pursue new challenges.

B. Loose and Autonomous Connections

Reference [5]-[10] proposed a new network model called "the Brokerless Theory" in 2001 from the perspective of network engineering. This later became known as "P2P (Peer to Peer)." In the P2P network model, computers or groups of computers can loosely and autonomously connect to each other, creating new value from these connections, without the need for servers positioned as brokers (intermediaries). This led to the creation of innovative services and business models such as Skype, SNS, P2P insurance [11], P2P electricity, virtual currency, blockchain, and NTT's grid computing service [12]. In this paper, the loose and autonomous connections proposed by P2P are simply referred to as "loose connections."

The mechanisms for constructing loose connections provided by the Brokerless Theory (i.e. P2P) include Brokerless, Servant, Simultaneous Participation Concatenation (Chain reaction) [13], [14], Self-Organization, Semi-Pure Model, Value in Connections, which means that connections are more valuable than individual peers, as well as grouping, in which a group emerges from connections among peers and the peer group itself functions as a single peer, as shown in Fig. 2-6.

Case1: Client Server Model and P2P model

Before the introduction of Brokerless Model (P2P Model) in 1998, the internet was generally based on a network model called Client Server Model. In Client Server Model, the server, acting as an intermediary for the clients, connects the

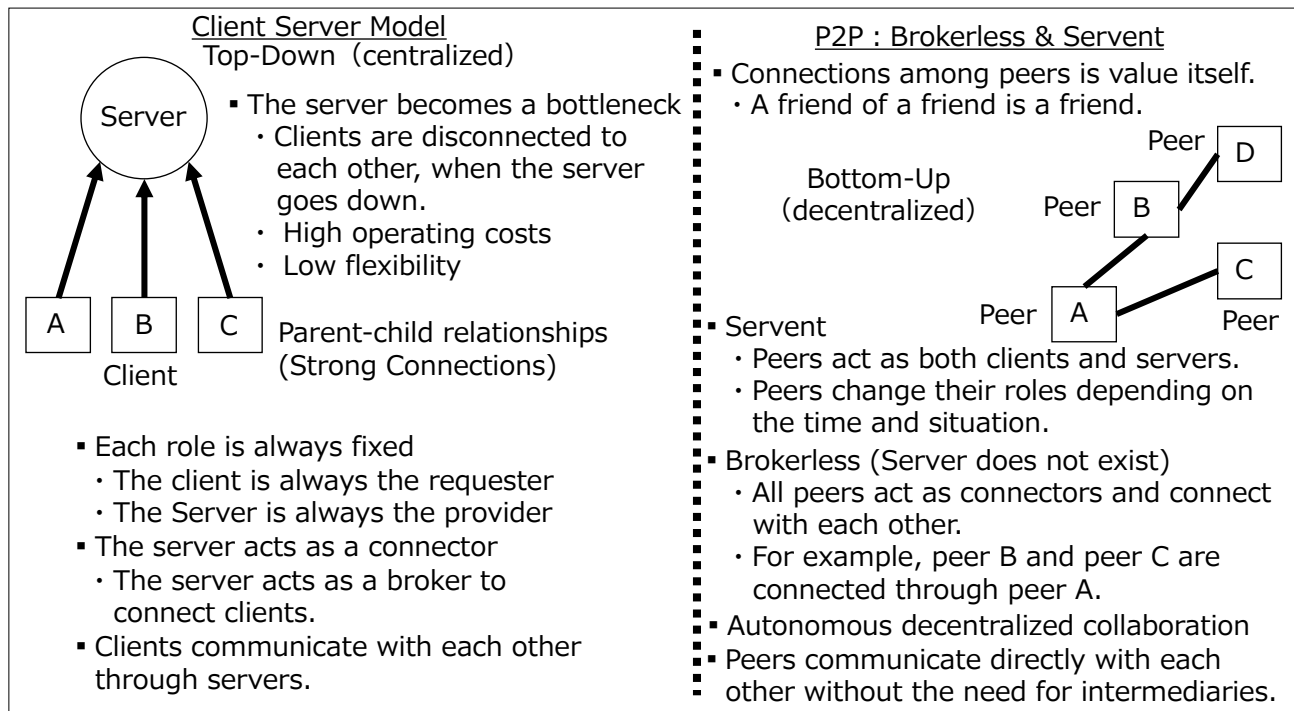


Fig. 2. P2P: Brokerless & Servent.

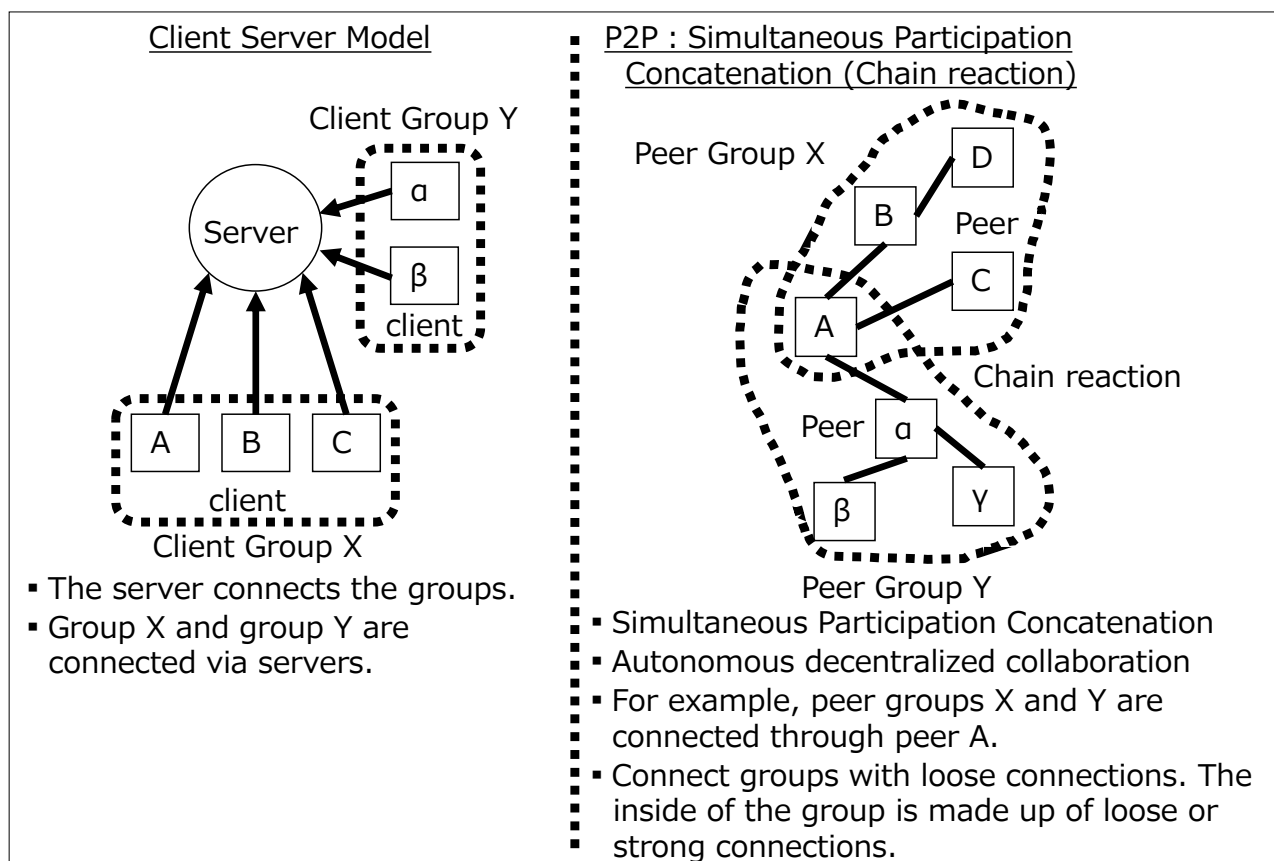


Fig. 3. P2P: Simultaneous Participation Concatenation.

clients to each other. This means that the server and the clients are connected by “strong connections (the Internal Vector)” like a parent-child relationship. This connection is top-down, based on a centralized architecture. Therefore, the client-server model has the following problems: the server's

processing capacity decreases as the number of clients increases, clients cannot be connected to each other if the server goes down, and the cost of operating the server becomes a burden. The strong connections come with substantial costs, making it difficult for new challenge and

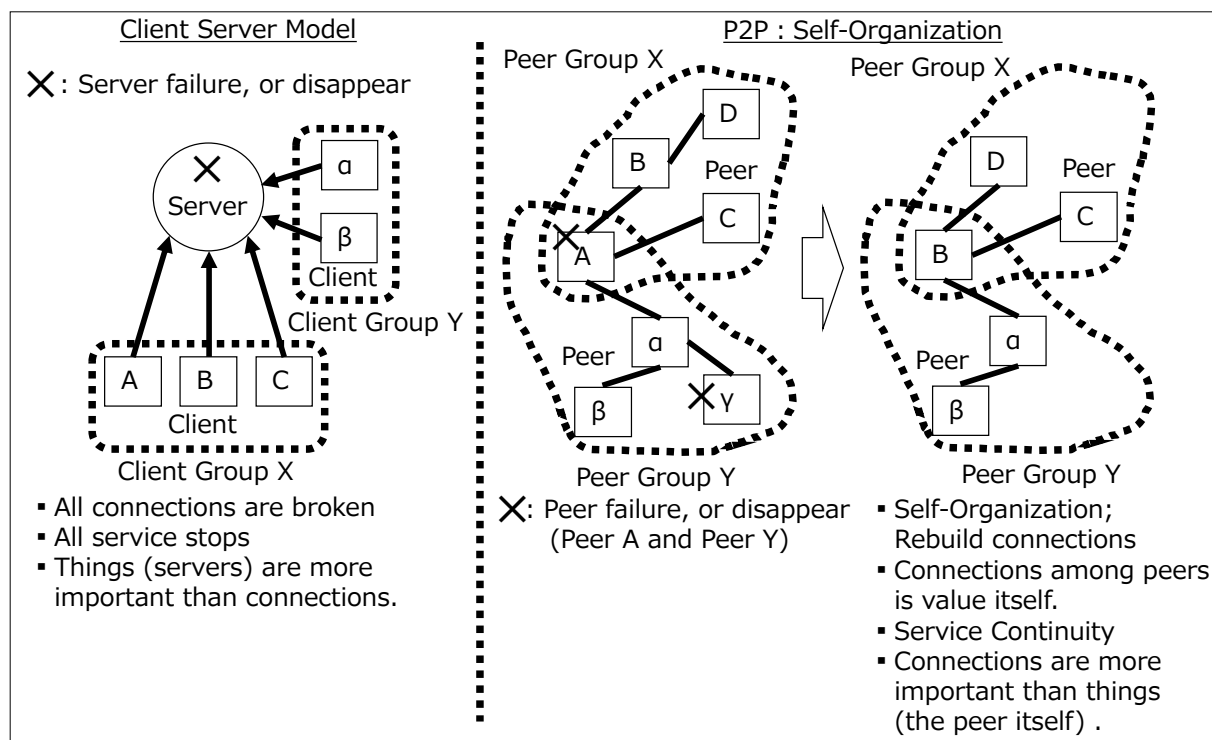


Fig. 4. Self-Organization & Value in Connections.

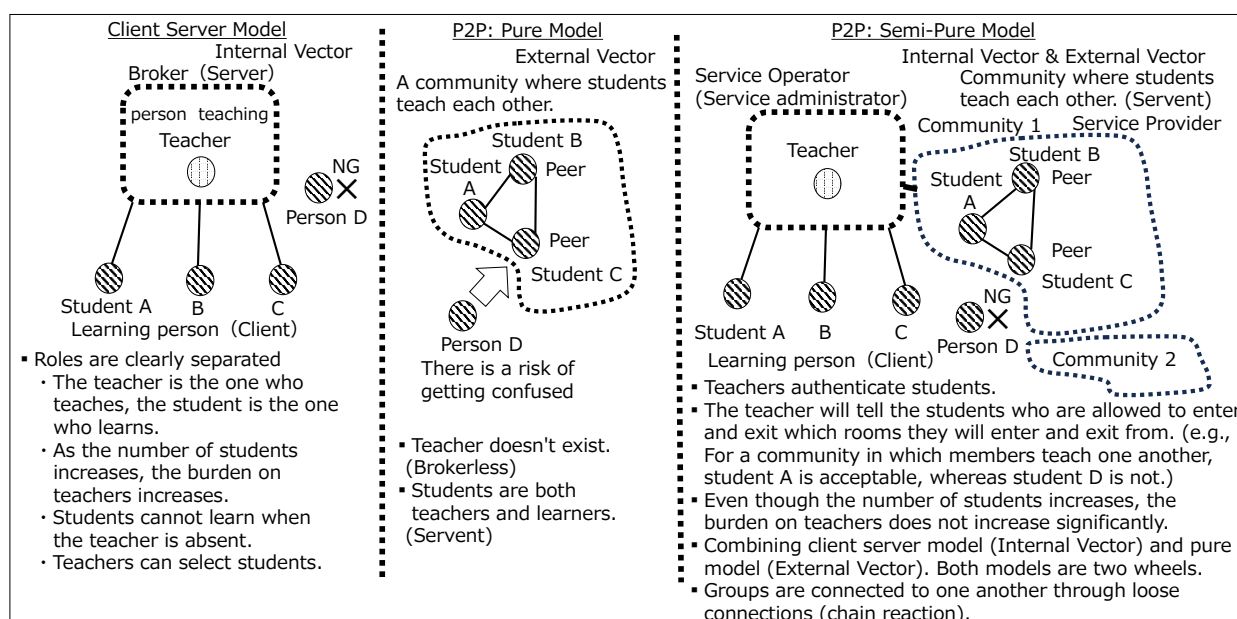


Fig. 5. Semi-Pure Model (a method for connecting the Internal Vector and the External Vector; e.g., a place for learning).

value to emerge.

In contrast, Brokerless Model (P2P Model) created new value by loosely and autonomously connecting clients without relying on the server's existence.

Case2: Problem-Solving and Regional Revitalization Platform

The problem-solving approach aims to solve various existing problems and difficulties. Most local government efforts have followed this problem-solving approach. Since the goal of this model is to solve the problem, it has been less likely to lead to the emergence of new values or

transformation (e.g., social or organizational transformation).

On the other hand, it is crucial for innovation creation to construct a platform, that is, a logical framework, which integrates and the data, practical knowledge, and expertise obtained through individual problem-solving activities in order to promote the creation of new values and broader transformation. In other words, "the cross-cutting (horizontal) linkages" among individual activities promote the creation of new values and transformation.

Therefore, references [15] and [16] proposed a hierarchical structure for regional revitalization, innovation and DX. It will be layered into regional revitalization applications and

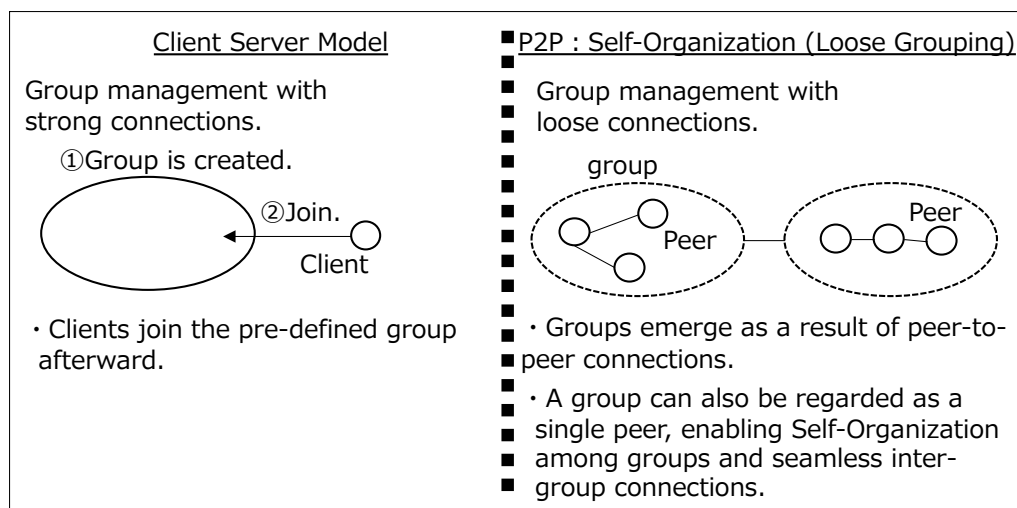


Fig. 6. Self-Organization (Loose Grouping).

regional revitalization platforms. This was inspired by the fact that ICT systems are composed of two layers: applications and an operating system.

However, if the regional revitalization platform is constructed and operated through strong connections (i.e., centralized and top-down connections), the associated cost and sustainability become major problems. Similarly, even in problem-solving approaches to regional revitalization, costs and sustainability tend to become significant concerns because the internal vector is directed toward problem resolution. Therefore, it is important to build a regional revitalization platform by connecting regional resources, which are positioned as constituent elements of the regional revitalization platform, through loose connections.

C. Diverse Connections

Reference [17] shows that it is valid to secure diversity and fusion of different fields in order to create new values. This means that no matter how many resources in closed areas such as within a single domain or a single industry, are connected, innovation is unlikely to emerge from them.

For example, on the internet, one can easily be surrounded by information to which one's hobbies, tastes, and ideas are close. Reference [18] pointed out that online advertising based on users' search and click history tend to provide information strongly connected to oneself. Furthermore, reference [19] mentioned that in the closed space of SNS, where users with shared empathy follow each other, one's thoughts and ideas are easily affirmed, leading to the illusion that one's ideas are correct. In other words, the internet environment makes it difficult to ensure diversity through connections built on "shared empathy and values," and new discoveries are hard to obtain.

D. New Connections

Reference [20] emphasized the importance of "new connections (new combinations)" between resources. This means that new discoveries and stimuli can be obtained from new connections, rather than from well-known and familiar connections.

For example, the QR code was invented through a novel combination of the well-known barcode and the board game Go.

III. THE NECESSITY OF VERBALIZATION AND TRAINING

This section discusses why verbalization (i.e., the establishment of a shared language) and training are necessary to construct connections through the External Vector.

Building new connections between diverse resources across different fields is not easy, given the differences in language, customs, and thinking in each field. It is not simple to build sustainable, reproducible, and general-purpose connections at low cost, low risk, and with high reliability.

For example, various cross-industry exchange meetings have been held nationwide. The goal is to create new values by connecting regional resources across different industries. However, in most of these efforts, no new values that would promote transformation have been created.

The main reason for this is that the connections between resources across different industries have not been verbalized (theorized). For example, there is a need for a "theory" that serves as a shared language that can be shared across all industries, such as "plus" and "minus," or "YES" and "NO."

Reference [21] pointed out the necessity of theory and the importance of balancing theory and practice by stating, "Practice without theory is a reckless act, and theory without practice is vain."

Similarly, many lectures by successful individuals have been held in seminars, but the success stories shared there are just one example and nothing more. On the other hand, to make success stories universal, they need to be generalized. In other words, rather than simply conveying successful experiences as examples and stories, it is necessary to perform scientific mapping for others by verbalizing and theorizing successful experiences.

References [22], [23] distinguish between "personal opinions" and "theories" and clearly demonstrate the usefulness of theory. They state that "mere success stories are regarded as personal opinions, whereas those that are verbalized and systematized can be considered theories." They further illustrate the value of theory with the following statement: "There are many successful entrepreneurs. However, it is not guaranteed that other entrepreneurs who follow their personal opinions will achieve similar results. In

TABLE I
COMPARISON OF GO-P2P SIMILARITIES, SHOGI-CLIENT SERVER SIMILARITIES, AND THEIR DIFFERENCES

External Vector		Internal Vector	
Go(IGO)	P2P	Client Server	Shogi(Chess)
- There are no predetermined roles for Go stones. - Go stones change their roles depending on the time and situation.	- Servent (Fig.2): Peers act as both clients and servers. - Peers change their roles depending on the time and situation.	Each role is fixed and never change; the client is the requestor, and the server is the provider (Fig.2).	The role of the pieces is fixed and does not change.
- Even if one territory or Go stones is lost, it is important to create another territory or connections among another Go stone. - Go is a game where players compete for territory through strategic give-and-take.	Self-Organization (Fig.4): If peers goes down, the remaining peers will rebuild and continue service.	All services stop when the server goes down (Fig.4).	The game ends when the king is captured, since the objective of the game is to capture the king.
- There is value in the connections between Go stones. - Each Go stone becomes a connector and connects the Go stones together.	- Connections among peers is value itself (Fig.4). - Brokerless (Fig.2): Since there is no broker that connects peers, each peer becomes a connector and connects to others, enabling mutual connections without reliance on any specific central entity. - Simultaneous Participation Concatenation (Chain reaction) (Fig.3): A peer connects peer groups.	- The server persistence has value in itself. - Broker / Server (Fig.2, Fig.3): The server functions as a broker that connects clients. When the server stops, the connections between clients are broken because the system depends on a specific actor.	- The lifespan of a king is value itself. - It is important to cooperate with other pieces centered on the king, such as capturing the opponent's king and protecting one's own king.
The game starts with no (zero) Go stones placed on the board.	The network or service starts with no (zero) peers.	A network or service starts after arranging servers in advance.	The game starts after the pieces are placed in predetermined territories.
Groups are formed as a result of stones being loosely connected. These groups can also be linked to one another through additional stones.	- Loose Grouping (Fig. 6): Groups emerge as a result of peers being loosely connected, and each group can be treated as a single peer. - Loose Grouping among groups (Self-Organization) enables easy inter-group connections.	Strong Grouping (Fig. 6): Clients participate in a group that has been created in advance.	A group of pieces is formed to defend the king. This strongly connected group centered around the king is called <i>Anaguma</i>.
A game that creates a good balance of weak and strong connections.	- A network in which peers are connected by "loose and autonomous connections". - Bottom-Up / decentralized - Semi-Pure (Fig.5) - Connect a server and a peer group.	- A network in which clients and servers are connected by strong connections. - Top-Down /centralized (Fig.5)	A game in which the king and other pieces are connected by strong connections.

※Reference [23] recommends "multitasking," where employees perform multiple tasks. Multitasking corresponds to servant and simultaneous participation concatenation in P2P.

contrast, a well-established theory, supported by rigorous research, can be regarded as having universality.”

At the same time, it is necessary to acquire the shared language (theory) for constructing connections through the

External Vector and to undergo training to utilize it.

This is because we must change our way of thinking from an the Internal Vector to the External Vector. In addition, in order to use the Internal Vector and the External Vector as

two wheels in a well-balanced manner, it is necessary to cultivate an awareness of connecting loosely. However, in the current situation where strong connections are practiced unconsciously as common sense, it is not easy to cultivate an intentional mindset toward weak and loose connections..

IV. SIMILARITIES BETWEEN P2P AND GO AND THE EXTERNAL VECTOR

In order to foster regional innovation and regional DX, it is necessary to create new values and promote transformation from the connections between regional resources. Based on an analysis of previous studies, Section II clarifies that, in order to foster the emergence of new values and promote transformation in a region, it is necessary not only to form strong connections (the Internal Vector) among regional resources, but also to newly construct weak and loose connections across different fields. We defined these connections as the External Vector. They are decentralized and bottom-up connections. It is essential to balance both the External Vector and the Internal Vector, and the mechanisms for doing so are the Semi-Pure Model in Fig. 5 [16] and the Simultaneous Participation Concatenation (Chain reaction) in Fig. 3 [13], [14].

Moreover, in order to newly connect diverse regional resources across different fields through the External Vector, the sustainability of which is difficult to ensure, it is necessary to establish a theory (i.e., a shared language) and training for its practical implementation (e.g., cultivating awareness of making connections). In other words, the verbalization of connections and the training are crucial in order to construct connections through the External Vector, leading to regional innovation and regional DX.

Regional innovation and regional DX are essentially

efforts to create connections through the External Vector, and for this, the P2P theory, which provides a theory for creating loose and autonomous connections, is considered optimal. Additionally, for training and cultivating awareness of building the External Vector, the board game of Go, which demand us to create a good balance between loose and strong connections, is considered effective.

Furthermore, we proposed the idea of combining the “concepts and principles of P2P” and “those of Go.” As shown in Table 1, to clarify the effectiveness of combining P2P and Go, we evaluated (a) the similarities between P2P and Go, and (b) the similarities between the Client Server Model and Shogi, the Japanese chess game. Moreover, we evaluated the differences between (a) and (b).

In addition, since P2P and Go have a high affinity with the External Vector, synergy effects can be expected by combining them.

V. EVALUATION OF THE EFFECTIVENESS OF COMBINING P2P AND GO

To examine whether Go is effective as a training method for constructing connections through the External Vector, a questionnaire survey was conducted (see Fig. 7). The participants were 486 individuals who completed both the shared-language training (training time: 90 min × 6 sessions = 540 min) and the Go training (training time: 90 min × 6 sessions = 540 min). First, the questionnaires for Q1 and Q2 were administered after conducting only the shared-language training. Next, the questionnaires for Q3 to Q5 were administered after conducting the Go training.

The first question, “Q1: To what extent were you able to learn the concepts and principles of P2P as a shared language for building connections through external vectors?,”

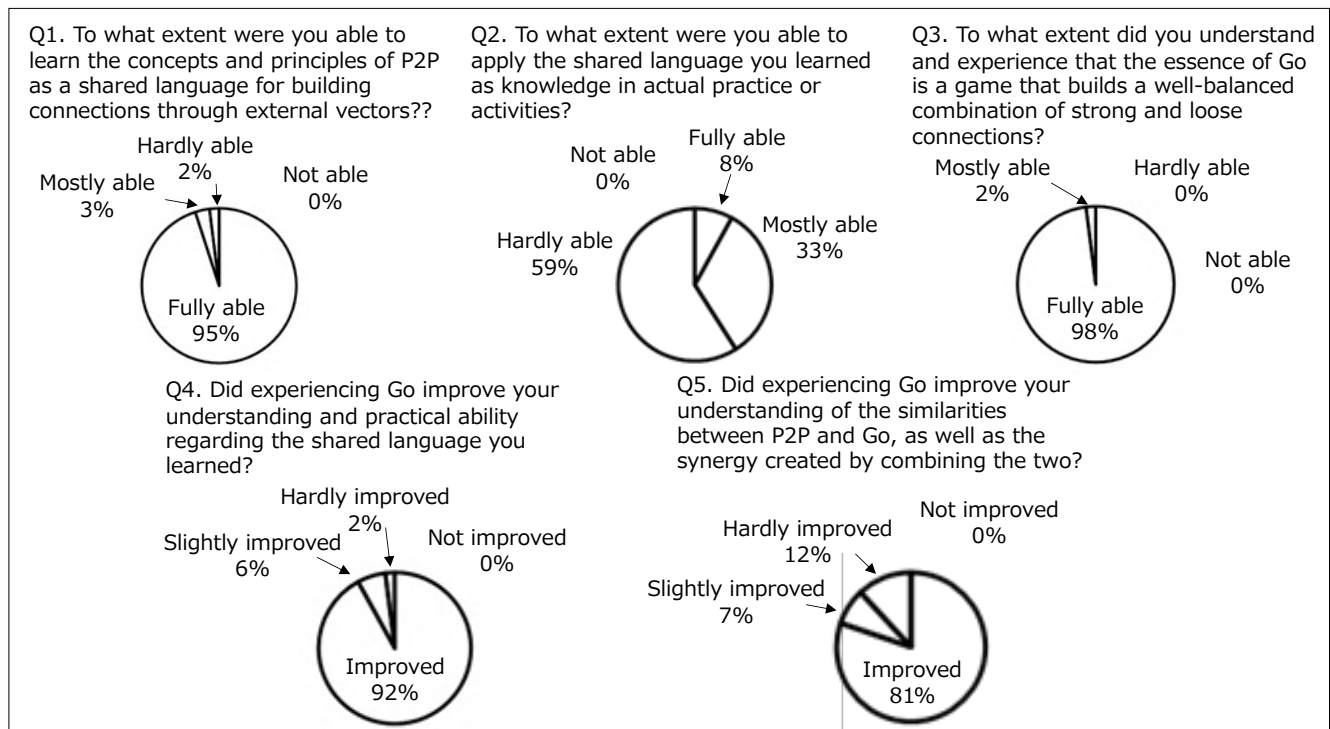


Fig. 7. Results of the questionnaire survey.

indicated that 95% of participants selected “Fully able,” indicating a high level of understanding of the content.

The second question, “Q2: To what extent were you able to apply the shared language you learned as knowledge in actual practice or activities?”, showed that 59% of participants selected “Hardly able,” indicating that many found it difficult

to apply the shared language in practice. This result suggests that although participants could understand and acquire the shared language for constructing connections through the External Vector as knowledge, it was not easy to actually utilize it in practice. The main reasons given for this difficulty were as follows:

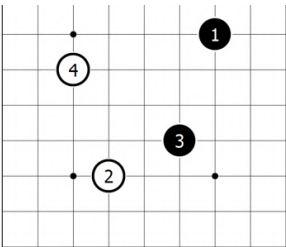
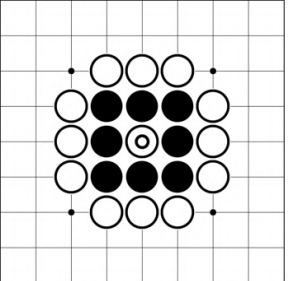
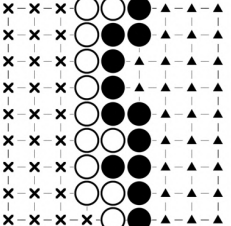
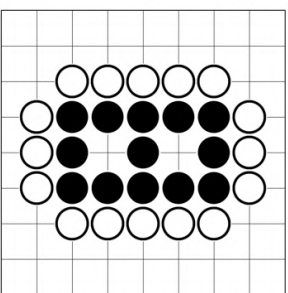
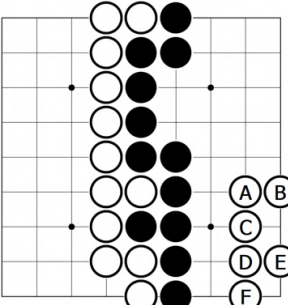
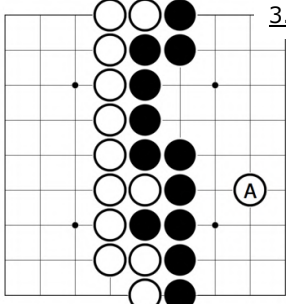
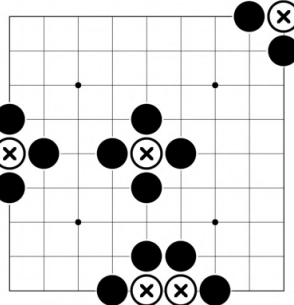
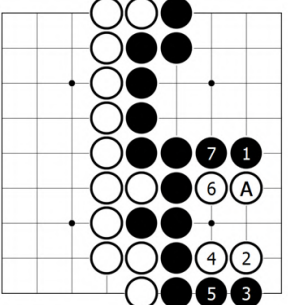
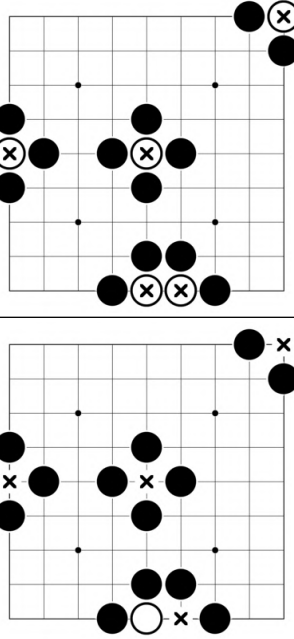
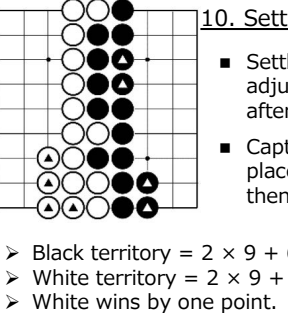
The number of possible move patterns is approximately 10^{360}. 	1. Basic Rules of Go ■ Use a board, White stones and black stones. ■ Black plays first, and players take turns alternately (i.e., Black→White→Black→ ...). ■ Stones are placed on the 19×19 intersections of the grid lines on the board.	6. Exception to the Suicide Point Rule ■ A player may place a stone on a forbidden point only if doing so captures the opponent's stones. ■ As shown in the left figure, White can place a stone on the ○ point because it captures Black's eight stones. 
 2. How the winner is determined ■ Create territories by surrounding empty areas. ■ Make the boundary line between Black and White clear. ■ Once both sides agree that all boundaries are settled, they pass. When both players pass consecutively, the game ends. ➢ Black's territory (▲) = $3 \times 9 + 2 = 29$ points ➢ White's territory (x) = $3 \times 9 + 1 = 28$ points ➢ Black wins by one point.	7. Two Eyes (3-②) ■ If two forbidden points are created, the group cannot be captured. ■ Even without them, the group remains alive as long as the opponent does not invade. 	8. Definition of Territory ■ White's ultimate goal is to create an invincible shape with two eyes. ■ White needs six stones to complete this shape. ■ However, During that time, Black also has six moves, which can be used to prevent White from forming the invincible structure. 
 3. When your territory is invaded ■ When White enters Black's territory, the boundaries of territory become ambiguous. ■ To handle this situation, Black takes one of the following approaches: ① Captures invading White stones. ② Prevent White from making two eyes (i.e., two separate spaces).	4. Capture Stones (3-①) ■ If you completely surround your opponent's stones, you can capture them. ■ Captured stones are kept aside, and at the end of the game, they are placed inside the opponent's territory to reduce the opponent's score. 	9. Definition of Territory ■ From steps ① to ⑦, Black pushes White to prevent White from forming two eyes. ■ As a result, White's four stones are captured and placed inside White's territory at the end. ■ Note: Captured stones reduce the amount of territory. ■ Key point: To prevent invasion, it is important to expand and secure territory. 
 5. the Suicide Point ■ A suicide point is a place where a player is not allowed to place a stone because doing so would immediately cause self-capture. ■ As shown in the left figure, White cannot play at the “x” point, whereas Black can.	10. Settling the Board (Counting Phase) ■ Settling the board is the process of adjusting stones inside each territory after both players pass. ■ Captured stones and dead stones are placed in the opponent's territory, and then each territory is counted. ➢ Black territory = $2 \times 9 + 6 = 24$ points ➢ White territory = $2 \times 9 + 7 = 25$ points ➢ White wins by one point. 	

Fig. 8 Rules of Go.

- 1) Under the prevailing circumstances in which strong connections are commonly formed, it was difficult to shift one's thinking and cultivate awareness from strong connections to loose connections.
- 2) It was difficult to construct a balanced combination of strong and loose connections, and the appropriate timing for switching between the two was hard to determine.

The third question, "Q3: To what extent did you understand and experience that the essence of Go is a game that builds a well-balanced combination of strong and loose connections?", demonstrated that 98% of participants selected "Fully able" and 2% selected "Mostly able," meaning that all participants demonstrated positive understanding and experience regarding the essence of Go. This result indicates that through Go, participants were able to experience a shift in thinking from strong connections to loose connections, cultivate awareness, and grasp the appropriate timing for switching between the two.

The fourth question, "Q4: Did experiencing Go improve your understanding and practical ability regarding the shared language you learned?", indicated that 92% of participants selected "Improved," indicating a substantial increase in both understanding and practical ability after experiencing Go. This represents a significant improvement from 59% (Q2) to 2% (Q4) before and after the Go training. This result demonstrates that Go is effective as a training method for constructing connections through the External Vector.

The final question, "Q5: Did experiencing Go improve your understanding of the similarities between P2P and Go, as well as the synergy created by combining the two?", revealed that 81% of participants selected "Improved," indicating enhanced understanding of the similarities between P2P and Go and the synergy gained by combining them. This indicates that for understanding and practicing a shared language, it is effective not only to learn the theory (verbalization method) alone but also to combine it with Go.

From these results, it is clarified that Go is effective as a training method for the External Vector, and that due to the high degree of similarity between P2P and Go, combining the two yields a significant synergistic effect.

VI. CONCLUSION

This paper analyzes the problems related to fostering regional innovation and regional DX, revealing that the External Vector is effective in creating new values. It also proposes a new method for fostering regional innovation and regional DX by combining Go and P2P, and quantitatively demonstrates its effectiveness through a questionnaire survey. For reference, the rules of Go are illustrated in Fig. 8.

The essence of the External Vector (P2P) is to create new value through loose connections. Therefore, we are advancing initiatives that generate new value by loosely connecting regional resources dispersed throughout the region using the External Vector. For example, the Sojo University IoT/AI Center is operated by a community built through loose connections between companies, local governments, universities, students, high school students, citizens and financial institutions. This has made it possible to operate an IoT/AI center with high sustainability, reproducibility, versatility, and reliability at low cost [24].

In future work, we plan to conduct demonstration experiments of industry–government–academia–finance collaboration using the proposed method through the Aso City Regional DX Promotion Council [25], the Local Government Collaboration Platform Council, and high school student platforms.

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