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APPLICABILITY OF TELEWORKING IN SOFTWARE DISTRIBUTED DEVELOPMENT

Abstract:

The purpose of this research is to confirm the possibility of personnel participation in a software development project remotely. Modern system development projects require secure specialist personnel with a wide range of technical capabilities to satisfy the diversified customer needs and the remarkable technological advancement. Nevertheless, many Japanese companies are oriented toward centralized development. There are limited people in the organization with the latest technology, and their work orientation is not uniform, making it difficult to realize intensive development. These trends are not limited to the IT industry. At the same time, the Japanese government recommends that companies adopt teleworking in order to provide flexibility to their employees and improve their quality of life. In research, teleworking has become a trend in current software development environments, confirming the possibility of distributed software development in the IT industry. Here, we propose a teleworking system configuration for such distributed development.

Keywords:

Revising Workflow, Software Distributed Development, Personnel, Remote Participation, Telework

JEL Classification: L86, D39

1. Introduction

Systems designed to address the needs of modern society are larger, more sophisticated, and more complicated than ever. Their design and development require a wide range of technical skills. Moreover, it is often necessary to develop these systems fast and at a low cost, due to the competitive pressures in the domestic as well as the global environment.

These principles also apply to information system development. In order to develop successfully a large-scale and complex system in accordance with the customer's request, specialists with the necessary skills must be secured temporarily, but also immediately. Since this may sometimes be difficult, other alternatives are collaborating with other development groups such as internal organizations, subcontracting companies and/or individual proprietors, and decentralizing the development environment to solve geographical problems.

Recently, the Japanese government issued the measure "Revising Workflow and System," which aims to reform the workplace, by promoting teleworking as a means to support workers' flexibility and ultimately life quality.

Since the World Wide Web was invented in 1990, the Internet has been established as an infrastructure for daily life and the IoT (Internet of Things) is increasingly introduced. At the same time, the information system environment of a company has been changed from the era of centralized processing by a host computer to client-server distributed processing. Today, its form has changed even further to network-based centralized processing, incorporating cloud computing and mobile devices.

In development, not only the traditional waterfall type development model but also the Agile development model represented by Scrum aim at fulfilling the customer's requests through a centralized development environment. Considering development efficiency, these models are now reevaluated.

In this research, we examine the applicability of teleworking for distributed development that can satisfy both corporate and developer demands. Furthermore, we review concentrated development as the currently proposed model.

2. Literature Review

Here, we present the terms distributed development and system development, as defined in previous research, and investigate the background of the system

development environment, the circumstances, and the history of the development model. In addition, we examine the general trends in work methods from the viewpoint of the workers' side.

2.1 Definitions

2.1.1 Distributed Development

Distributed development is the "development of software and computer systems at multiple sites at the same time." In the distributed organization environment, development may take place at different departments of the same company, or at different companies such as a trust company or a trust company. This term also includes offshore development that comprises overseas enterprises with low labor costs and home offices where individuals work at home.

2.1.2 System Development

In system development, system engineers basically grasp work mechanisms, analyze requirements, and design systems based on these requirements, whereas programmers actually develop the systems based on these designs. Information system development incorporates the introduction and operation of the software, whereas software development corresponds to the program development phase. Here, software development is included in system development.

2.2 Background of system development environment

In this section, we review the history and trends of the system development environment, in order to clarify the historical position of the distributed environment.

2.2.1 Changes in the computer environment

The computer environment has been repeatedly concentrated and dispersed, and, until the 1980s, the "mainframe" was its most important component. Ever since the 1980s or even later, personal computers (PCs) and UNIX/PC servers were replaced mainframes. Then, client servers were mostly used, and, in the 1990s, the era of "distribution" came about (Vaskevitch, 1994).

In 2000, the "ubiquitous network," which managed input data from computer devices on the network, attracted attention. In the second half of the 2000s, servers all over the world "concentrated" to Cloud I. After 2010, we have been returning to a centralized

development environment with cloud/computing development and Agile development like Scrum.

The former ubiquitous network environment has been transformed into a distributed environment, where the influence of IoT and the throughput of computers in network devices are expected to increase in the future.

Through all these changes, system development and the computer environment have evolved in parallel.

2.2.2 Evolution of the development model

The framework of the Software Development Method is the system development life cycle presented by Elliott (2004), and it is the oldest formalized methodology framework for building information systems. From there, methodologies, processes, and patterns are used as a flexible framework that organizations use to generate custom steps tailored to the needs of a particular project, from the specific procedures that an organization can directly use in their daily work.

Royce (1970) presented the development management process and the waterfall development model for a large-scale software system. Since the US mandated it, this model and the process have been standardized and promoted in project development. In the waterfall development mode, the deliverables of each process were determined on the basis of the model's assumption that "there is no mistake in the previous process." This made the distribution development easier to take over to the next process. However, if there was a mistake in the previous process, it was difficult to modify the model. Thus, the iterative development model was created in the second half of the 1980s. This model, which is typically represented by Agile, has become the recommended model in the US since the latter half of the 1990s, and it was mandated from 2000 onwards.

Table 1 shows the results of a comparative study by the "Non-waterfall–type development Working Group" of the IT Promotion Agency on the advantages and disadvantages of the development environments established in the US and Japan (IPA, 2012).

Table 1: Features of the Development Environment

(Japan vs. US)

	Overseas (mainly U.S.)	Japan
1	In-house development (without contract)	Entrusted development (with contract)
2	To facilitate communication between the customer and the development team even if the customer is offshore.	Difficult to have communication due to contract and/or physical working distance.
3	In-house IT engineers	IT engineers are subcontracted through a system integrator or an external software development house

Source：（IPA,2012）

In this survey, the diffusion factors of Agile development are mostly attributed to in-house production. In other words, the factors that impede popularization in Japan are especially found in the distributed development environment of large-scale development. In fact, there are many causes, where difficulties in communication are attributed to the physical working distance between the people participating in the development.

Nevertheless, the possibility and the actual conditions of teleworking application are suggested in the statement that overseas "mainly offshore, mainly in the US, customers and development teams are creating an environment, where they communicate with each other." This clearly indicates an environment that can overcome geographical distance, even in Agile development.

In addition, Boehm (2003) proposed the following systems as alternatives, for overcoming the problem of choosing between the Agile development method and the plan-oriented development method:

a. Systems, in which experienced developers participate

b. Systems that require frequent changes during development

c. Systems with few developers

 Even in 2003, the conventional plan-oriented development was a method to be used by many experienced developers, whereas the Agile development method was described as a method for less skilled developers. Table 1 shows that securing a few skilled developers still plays a significant role in the success of the project, despite the increasing iterative development ratio including the Agile development model.

2.3 Measures for work flexibility

In this section, we review the literature on the current workers' perception of the work method, the government's measures, and the actual situation in Japanese enterprises. This will be the basis for considering the application of distributed development.

2.3.1 Measures taken by the Japanese government

The Japanese government, in the reform implementation meeting at the Prime Minister's Office in March 2017, issued the measures "Planning how to work from the viewpoint of workers" and "Plan for implementing reforms of workers," following socioeconomic pressures associated with the workplace conditions. In fact, considering globalization, recent technological advances, and the subsequent expectations of workers regarding the lifestyle and quality of life, the working environment is much more diversified than in the past.

What is changing is not only the environment but also the values of people who are workers. The young generation of workers has radically different views and much higher expectations from their work. But in the past, workers followed corporate orders unlimitedly; young workers demand work–life balance and flexible working conditions to accommodate their own lifestyle. There is a tendency to put as much value in income as in work satisfaction.

2.3.2 Status of Japanese companies

In enterprises, crowdsourcing has expanded recently, and opportunities for work are increasing due to work methods not being dependent on employment contracts. Large enterprises have added remote work such as satellite office work and teleworking, and many small businesses encourage teleworking with the aim of reducing costs by limiting the workplace.

IT companies are no exception. However, teleworking applied to some companies has not exceeded the trial level yet.

2.3.3 Penetration status of teleworking in Japan

To prevent such enterprises from hesitating to introduce teleworking, the government hould consider the flextime system, including missing hours and travel time in the

normal working hours system, as well as conditions for using the deemed working hours system outside the office. Specific application plans should also vary depending on the business characteristics and specific demands. Today, the introduction rate of teleworkers on the enterprise side is still low.

Figure 1: Trend of teleworker population
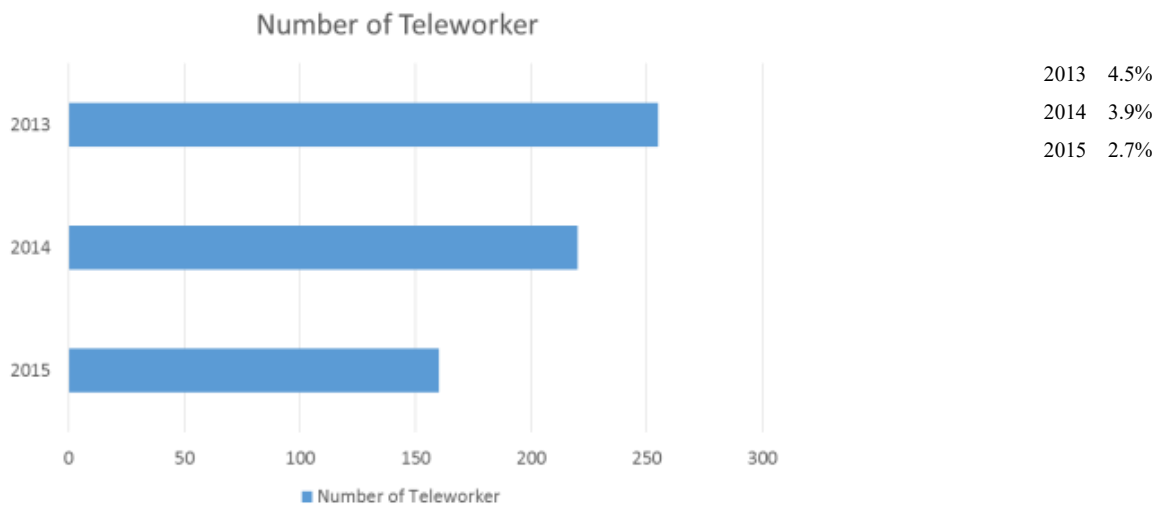
Source: (MLIT, 2015)

Figure 1 shows that the number of employment-type home-type teleworkers working at home at least 1 day a week is about 1.6 million, representing only 2.7% of all workers. In the enterprise teleworking introduction rate (MIC, 2008–2016), Figure 2 shows the trend of the proportion of teleworking introduction companies in recent years in the communication usage trend survey. The introduction rate has remained stable for the past 10 years, and even in 2016, the proportion of companies introducing teleworking was 13.3%, which is significantly lower than that of the US by 85%. Considering the company's number of employees, only 3% of the companies with fewer than 100 employees relative to 20.4% of those with more than 301 employees have introduced teleworking. In Japan, teleworking is recommended mostly for large companies (MIC, 2015).

Figure 2: Population of teleworking introduced company
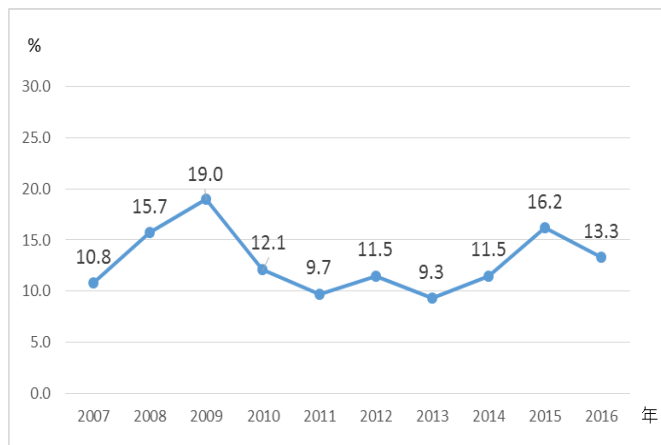
Source (MIC, 2008–2017)

2.3.4 Penetration status of teleworking in the US

In the US, teleworking began early, and it has become established. According to a survey by Worldatwork (2015), 85% of organizations (including nonprofit organizations and 22% public institutions) authorize the use of teleworking in certain cases (such as when an employee's child is sick) or on a weekly, monthly, etc. basis. Also, more than 50% of organizations approve periodic teleworking.

2.3.5 Industrial situation and obstructive factor in Japan

Considering the teleworking introduction situation in Japan (MIC, 2015) by type of industry, most IT companies have introduced teleworking, in contrast to other industries. In the questions "Teleworking has been introduced" and "Are you considering and/or interested," more than 52% of IT companies answered positively. It is estimated that ICT (Information Communication Technology) is the industry with the highest potential demand and feasibility of teleworking.

In the IT industry, it is not clear what type of jobs teleworking is being introduced or considered for. It is being considered for system development (11.3%) and system operation (7.4%), and it has already been introduced in research on ICT utilization and social problem solving (MIC, 2017). Although introduction is still low, there is clearly the possibility of further improvement.

Despite the numerous merits of teleworking and the workers' desire for a more flexible work style, the reasons for the low introduction rate in Japanese companies are still

unclear. MIC presented the task of introducing teleworking in 2017 in its report on "investigation research on ICT utilization and social problem solution." This report suggests the following measures that would lead to 20% decrease in operational costs: (1) securing of security, (2) proper labor management, (3) narrowing down the target business, (4) grasping the effect of introduction, (5) building an internal company that supports teleworking, (6) employees communicating with each other, (7) appropriate personnel evaluation, and (8) introduction of teleworking.

With regard to (2) and (7) in particular, Sato (2008) pointed out that there are instances when firms frequently loose labor hours due to teleworking, as labor management becomes more complex. In addition, most companies measure labor hours by looking at the workers' work journals. Thus, teleworking is difficult to evaluate. In order to appropriately establish the significance of these issues, the Ministry of Public Management, Home Affairs, Posts and Telecommunications (2017) conducted a survey of 3,384 companies in all industries in Japan, not focused on the IT industry, especially for system development work.

3. Application of distributed development

Here, we examine the applicability of teleworking as a means of distributed development in system development projects in the IT industry.

3.1 Hypothesis Planning

On the actual situation and intentions of small and medium-sized IT companies developing systems, considering the mainstream development model and the introduction rate of teleworking in telecommunications industry/system development, as suggested from previous research, the following hypotheses are formulated:

【Hypothesis 1.】

Currently, distributed developments including teleworking are not being carried out because of manager's concerns related to uncertainties such as work status, work progress, and communication condition due to the geographical distance between the workers.

【Hypothesis 2.】

However, the managers recognize the necessity of constructing a distributed development environment, in which workers can participate in development projects remotely, in order to support employees' (engineers) flexibility and to secure necessary external personnel.

3.2 Qualitative Research

In this section, we present the results of the interview survey on the main issues regarding the introduction of teleworking by companies that actually carried out distributed development in previous research and by those that had not. Both small and medium IT companies were considered. In Table 2, Company A designs and develops web pages through distributed development, whereas Company B focuses on system development and system operation and does not undertake distributed development. Both companies have around 20 employees, but only top executives responded to the interview.

Table 2: Researched IT companies

	Company A	Company B
1. Business Summary	Website development, design, Web system development	System outsourcing development, system operation
2. Number of Employee	26	21
3. Distributed Development	Implemented	Unimplemented
4. Remarks	The employees do not work remotely , but outsourcer of a part of the projects, about 20 (person) individual business operators implement distributed development. These operations are carried out online with the offices of individual business operators and their homes.	There were some employees who worked at home in the past, but they are not established as an in-house system and are not currently implemented.

The contents of the survey mainly consist of four factors that showed a high percentage: teleworking introduction challenges (MIC, 2017) as described in the previous chapter, (1) information security, (2) applicability of teleworking in the target business, (3)

communication,

Table 3: Results of interview regarding teleworking

Couse for Issues	Company A	Company B
（1） Information Security	Individual business operators carry out all work and employees with all the progress management and file sharing online with customers, but security problems have not yet occurred.	There were telecommuters in the past, but it was not a problem.
（2） Applicability of target business	The work content of individual employees is a clear content that can deliver deliverables. The difference between work with an individual business operator is that employees visit customers at the initial meeting of the project with customers and the subsequent work contents are basically the same as individual businesses	Each business's work content is clear, it is content that can deliver deliverables.
（3） Communication	Usually, employees, individual business operators, and customers communicate with each other by chat, so there is no particular problem.	Usually they use chat, in case of emergency they use the phone. They think that there is no problem even at remote locations by these.
（4） Personnel Management	Implementation of evaluation system focusing on results. Considering the evaluation method and work content, employees can also develop distributed development by teleworking, but it is uncertain whether they can work similarly as when they are at the office even at a remote place. Project management is also difficult, and there are many dedicated tools, but it is often annoying and obsolete. I would like to use a tool that can manage project management that is user friendly.	It is evaluated on a performance basis. Labor management is not particularly done for past teleworkers. In the future, if there are employees who need to work at home, we decide whether they are talented persons who can work remotely without problems. In the case of remote work, work efficiency (labor productivity) is hard to see and evaluation is difficult.

and (4) hearing about personnel and labor management as a problem in distributed development. The actual conditions of both companies are described in Table 3. Case A, in which distributed development is carried out within the individual business owned Company A, has not yet introduced internal personnel, and in order to examine the embodiment and method of teleworking, first we investigated the "issue" that is common.

3.3 Hypothesis Verification

【Hypothesis 1.】

Regarding Company A, which is mainly engaged in in-house development, but also concerning Company B, which mainly performs contract development, it is difficult for employees to manage labor and personnel, and distributed development has not been carried out. Distributed development of other companies or individual enterprises does not present obstacles, because there is no need for labor management and personnel evaluation. Hypothesis 1 was confirmed.

【Hypothesis 2.】

Regarding future use, we have not confirmed the necessity recognition in this survey. However, there was an intention under the condition that ① work efficiency is visible, and ② project management is easy.

3.4 Proposed solution

It is proposed that the "Cloud type teleworking system that can visualize progress in a distributed development project" as a solution for expanding the applicability of the distributed development environment in system development from confirmation of hypothesis by previous research and survey.

3.4.1 Purpose of the Solution and Overview

The purpose of the solution is "to have the necessary functions for implementing a distributed development environment, and at that same time the manager can confirm the execution status of the project and the work situation of each member." Figure 3 shows the outline.

Figure 3: Solution overview
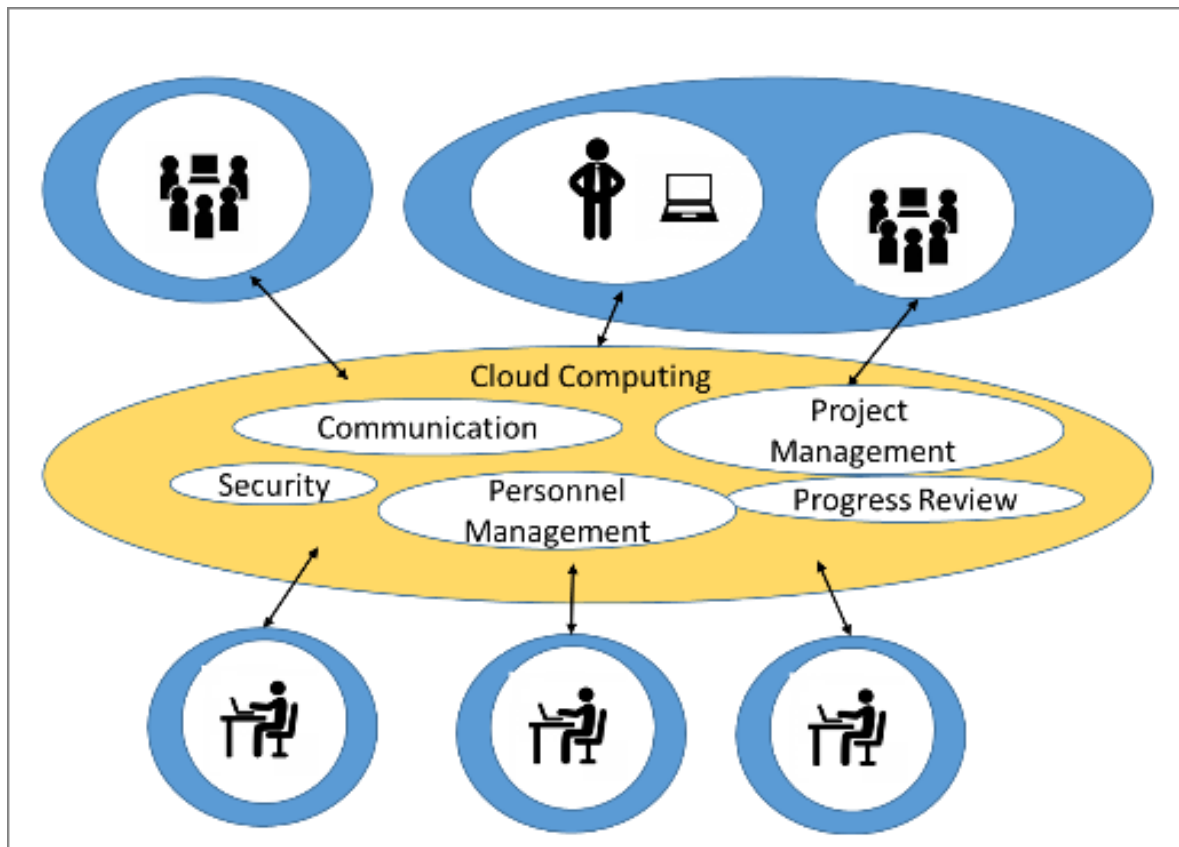
3.4.2 System function and configuration

This is a Web application that enables implementation and management of projects, confirmation of the work status of members, and communication. Table 3 shows the system functions and the application tools centered on the Google service used to realize them. Google services are already a group of services commonly used in offices. The advantages of this Google service are that (1) it can be used free of charge by setting up a Google account; (2) it is possible to share and edit contents with other users; and (3) because it is a Web application, it can be used from any terminal if it operates even a browser (Chrome).

By customizing the interlock ability so that they can be used for the project, it is possible to construct a basic distributed development environment easily and inexpensively.

Table 3: Application tool and functions

Purpose	Function	Application Tool
Project Management	Project Schedule	Google Calendar
	W B S	Google Spread Sheet Project Sheet planning (Add-on Tool)
	Problem Management	Google Spread sheet
	Deliverable Submission	Google Site
Labor Management	Attendance Management	Google Spread
	Status Management	Google Spread Sheet
Communication	Bulletin Board	Google Site
	Chat	Google Hangout/ Google Meet
	Tele conference	Google Hangout/ Google Meet
	Vide conference	Google Hangout/ Google Meet

4. Consideration

After developing this solution, we attempted to operate a distributed environment inside the university. The following task is the trial test in the enterprise project to confirm its applicability. We confirmed the hypothesis through the enterprise survey, but the survey included only two small and medium enterprises.

In addition, we considered the implementation of quantitative research to a larger number of samples with more detailed survey items to see the necessary functions for distributed development and for more accurate analysis. The proposal to apply familiar Google service functions to distributed development projects is expected to provide an environment that satisfies the needs of both companies and organizations, both managers and specialists.

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