Improving the Performance of Construction Project Information and Communication Management Using Web-Based Project Management Systems (WPMSs)

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ABSTRACT

This paper presents a brief study undertaken for improving the performance of information and communication management of construction projects through investing in information and communication technologies (ICT). The work aims at first to investigate and diagnose the problems, challenges, weaknesses, and inefficiencies related to information and communication management in projects in the construction industry of Iraq. Studying the diagnosed matters and the different solutions of ICT to improve project management performance is following the investigation process. The research presents a technological system suggested to process a lot of the diagnosed problems, challenges, weakness, and inefficiencies of the construction projects and to improve the current performance of project management and execution. The suggested system principles and fundamentals, benefits, features, classification and types, and the different solutions are described to ease and improve the process of development, adoption, and implementation of the system. The results show that the proposed system can improve the performance of the current state of project management through improving the processes of information and communication management.

Key Words: information and communication management, information and communication technology (ICT), construction industry, web-based project management systems (WPMSs).

تحسين أداء إدارة المعلومات والاتصالات في المشاريع الإنشائية باستخدام أنظمة إدارة المشاريع التي تعتمد على تكنولوجيا الويب

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الخلاصة

يقدم هذا البحث دراسة موجزة تهدف إلى تحسين أداء إدارة المعلومات والاتصالات في المشاريع الإنشائية في العراق. يهدف العمل أولا" إلى تقصي وتشخيص المشاكل، التحديات، نقاط الضعف، العمليات غير الكفؤة وغير الفعالة المتعلقة بإدارة المعلومات والاتصالات في المشاريع الإنشائية في العراق. يتبع هذه العملية دراسة وتحليل لهذه الأمور المشخصة ودراسة الحلول المختلفة لتكنولوجيا المعلومات والاتصالات لمعالجة هذه الأمور وتحسين أداء إدارة المشاريع. يقدم البحث نظاما" مقترحا" لمعالجة الكثير من المشاكل والتحديات ونقاط الضعف والعمليات غير الفعالة المذكورة أعلاه للنهوض بالمستوى الحالي لإدارة وتنفيذ المشاريع. تم في هذا البحث توضيح أساسيات النظام المقترح وفوائده وميزاته وأنواعه من اجل تسهيل عملية بناء وتبني وتنفيذ النظام وجعله أكثر

فعالية أثناء الاستخدام. تظهر النتائج اهمية النظام المقترح وفعاليته في تحسين عمليات ادارة المعلومات والاتصالات وتحسين اداء ادارة وتنفيذ المشاريع.
الكلمات الرئيسية: إدارة المعلومات والاتصالات، قطاع التشييد، تكنولوجيا المعلومات والاتصالات، أنظمة إدارة المشاريع التي تعتمد على تكنولوجيا الويب.

1. INTRODUCTION

The construction industry has unique characteristics, for instance the construction industry is fragmented due to the many phases and non-frequent activities and tasks involved in a construction project, and also the construction project involves many organizations and individuals from different sectors participate in project execution, and these participants are different in their working times, roles and jobs, tools, objectives, requirements, and goals in the project and their objectives may conflict in many cases. The construction projects are also characterized by large investments, size, complexity, and plenty of execution methods and techniques, and contracting types. These characteristics and others have increased the complexity of construction projects, and the amount of information that needs to be managed and processed during the construction of projects have increased a lot, and the project sites became intensive environments with information that needs to be managed more effectively and efficiently. The successful execution of construction projects depends heavily on information communication processes such as information availability, information exchange, collaboration, and coordination. The effective and efficient communication and information management gives more opportunities for project members to control, organize, and monitor projects execution and management, where the project members can better manage changes, transmittals, decisions-making processes, problems, risks, and other project items.

Very large amounts of expenses, efforts, and times are spent on executing construction projects over the world. In Iraq, the expenses and times spent on developing and improving the performance of projects management compared to the expenses and times spent on projects execution are relatively very low and are not compatible with the current projects that are characterized by complexity, expansion, dispersion, tighter schedules and standards, more requirements and expectations, and more challenges and problems. There are a lot of problems, challenges, weaknesses, inefficiencies, and inefficacies involved in the construction projects currently, therefore improving and developing the current performance are required intensively to promote the current level of project management and execution.

According to the aforementioned reasons, lots of benefits and savings can be obtained by improving the current performance of project management even when these changes be small. Information and Communication Technology (ICT) offers a lot of opportunities to develop the construction industry, which have proved its large and clear importance and effect during the last three decades in all industries especially the construction industry. The construction industry has benefited a lot from different ICT solutions, which motivated the organizations in the construction industry to invest in ICT largely. One of the most important topics that have been given high attention by the researchers and organizations in the construction industry is to develop and improve the performance of project and information management through adopting Web and Internet technologies, especially "Web-Based Project Management Systems (WPMSs)". These systems allow project members to manage

project processes, information, and communications online in real-time, and to access all project information anytime and anywhere with less time, effort, and expenses.

2. CONSTRUCTION INDUSTRY CHARACTERISTICS, PROBLEMS, AND CHALLENGES

In order to identify, investigate and diagnose construction industry characteristics, problems, and challenges, two processes were undertaken to support that. The first process was a review to the most recent literature and researches related to the topic in the construction sector. The second process was a survey (Questionnaire) undertaken in the Iraqi construction sector. A sample of 87 questionnaire forms were obtained from the survey process. The respondents were from construction organizations and from different specializations including Civil, Architect, Electrical, Mechanical and other Engineers. **Table 1** shows the functional positions and percentages of the respondents.

Table 1. The percentages and functional positions of the questionnaire respondents.

Functional Position	Percentage
Engineers	29
Senior Engineers Head	25
Head of a Section	16
Project Manager	13
Senior Engineer	8
Head of a Department	3.4
Consultant	3.4
Site Manager	1.2
Vice Engineers Head	1.2

The questionnaire involved closed-ended questions and open-ended questions. It was divided into six parts. The first part aims to collect general information about the respondents. The second, third, fourth, and fifth parts include closed-ended questions aiming to investigate the characteristics of construction industry, the management of information and communications, the current state, and the information and communication technologies currently used, respectively. The sixth part involves open-ended and optional questions. In this part, the respondents were asked to give their opinions about the most important problems in the construction industry and project management, and to give their suggestions to improve the performance of project management.

The data obtained from the questionnaire was analyzed using Statistical Package for the Social Science Program (SPSS, Version 20). The SPSS was selected because it provides useful and suitable tools for manipulating the work of analysis. The analysis of data was undertaken depending on determining frequencies and percentages of questionnaire variables (questions). Both weighted and unweighted analysis cases were considered in the process. The weighted case is based on considering the general information of the respondents involving engineering field, academic degree, functional position, years of experience in the construction sector, type of the organization, geographic distribution of the projects, and participation of the respondent in project management. For each item of these respondents' general information specific factors were taken in the analysis process called weighing factors. These factors were assumed based on several resources such as survey (with engineers have enough experience in the construction sector) and previously accomplished researches. Because the results obtained from the weighted analysis case give more reasonable

results, the weighted case was adopted when discussing the results of the questionnaire process. In addition, measures of center and dispersion were calculated to identify the tendency of results of the analysis. The results of the two processes can be illustrated as following:

- The construction sites are intensive environments with information generated, collected, stored, transferred, received, etc.
- A lot of information, data, documents, and files in project sites require less time as possible to be transferred, received, processed, etc. among project members.
- The project progress depends widely on communicating the required information at the right time among project members.
- The geographic dispersion of the locations of the projects and the project members make one of the challenges facing the communication of the required information at the right time.
- The construction projects involve many parties and individuals dependent on each other, which require that the methods and processes of communication and information exchange being more effective and efficient.
- The project sites are reactive environments, where changes, problems, and unexpected events and circumstances occur frequently, which require continuous and effective communication among project members during the construction of the projects.
- Continuous and effective communication among project members is very important consideration for monitoring project works, directing, coordinating, collaborating, and solving problems at appropriate times.
- Effective information management helps to increase and improve the productivity.
- Effective and efficient planning for information and communication management in the early stages of projects is required heavily.
- Effective communication among project members helps to manage effectively the goals and expectations of project members, reduce reworks and losses, and reduce the cases of information lack or wrong interpretation.
- A lot of problems and time losses occur in the projects because of inefficiency and ineffectiveness of communication and information management.
- Lots of time, effort, and expenses are spent on the processes of transferring, distributing, and updating information and data in the projects.
- There is urgent need to improve the current management techniques to suit the current projects.
- The results showed that the electronic applications such as email, Internet, Mobile Phone, and project management programs such as Microsoft Project are used largely and intensively in the projects, this due to their effectiveness in communicating and processing information in less time, effort, and expenses.
- There are a lot of obstacles and problems that intercept the processes of communication and information exchange among project members during the construction of the projects.
- Interference of tasks and functions of the project members during the construction of the projects.
- Retardation of communication of information and files during the construction of the projects.

- A lot of breakdowns and delays happen in the projects due to lack or loss of some information during the construction of the projects.
- A lot of errors and delays happen in the projects due to retardation of communication of information at the right time.
- Plenty of expenses, time, and effort are spent on movements between sites (project and project members' sites) in order for information.
- Plenty of time, effort, and expenses are spent on the processes of updating information, distributing new information, preparing reports and logs, and distributing them among project members.
- Weakness of processes of communication and information exchange among project members.

3. INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN CONSTRUCTION

Information and Communication Technology (ICT) has competitive solutions to the problems and challenges of project and communications management. The great advances in information and communication technologies made large changes in the construction industry over the world. Experts identified the benefits of ICT for managing construction projects as follows: richer information to improve decisions-making processes, easier and quicker access to project information, improving communication among project members, better relationships between project members, better information flow, better project control, and better management of geographically dispersed project sites and project members' sites, **Yang, Ahuja, & Shankar, 2007; Love, Irani,** and **Edwards, 2004; Root & Thorpe, 2001; Egbu, Gaskell, and Howes, 2001**. One of the most important solutions that have been given high attention from organizations and researchers in the construction industry is to improve the performance of project management and execution through Internet and Web technologies. All industries and especially construction industry have benefited a lot from applying the applications of these technologies.

4. THE PROPOSED SYSTEM

The system proposed to improve and enhance the processes of project management and execution is the project management application software that depends on Web and Internet technologies to provide remote, continuous and instant communication and access to project information and to manage the projects of an organization centrally online in real-time among project members. This type of system called web-based project management systems (WPMS). The Web (World Wide Web) is a system of interlinked hypertext documents accessed via Internet, **World Wide Web, 2013**. WPMS depends on application software, Web, and Internet technologies. WPMS can be described as a repository, communication station, and project processes manager. All information related to organization's projects is stored centrally in the system and in its different forms such as schedules, documents and files, text, pictures, charts, tables, videos, etc. to be available for project members anytime and anywhere. Internet is used in the system as a medium by which project members (system users) can access the system and its stored information. While the application software is used to manage project processes and information. Software and web-related information are installed on specific servers in the system. For every project of an organization's projects, there is a specific space on the servers and website called project website. Through the project website, the project members can access the project-related information and manage the different project

processes. **Fig.1** shows a simple model of WPMS configuration. One website may involve too many pages that show project information. The pages of websites contain hyperlinks used for navigating between the pages of websites. The information and pages of websites can be viewed using an electronic browser called Web Browser such as Internet Explorer, Google Chrome, and Mozilla Firefox. Application software, Web, and Internet form a system can be working without time and place constraints.

The availability of information or the ability to reach it through Internet does not mean that anyone can access it, but only those who have the authority given to them by system administrator or project manager. The individuals that have the authority to access the system and its stored information and do the different processes in the system are called system users. The system administrator is an individual has maximum permission in the system and can add, disable, remove, etc. users and determine their levels and the information they can access and the processes they can do in the system. Every user in the system has its own ID that identify the user into the system through secret data can be considered as a key to login the system. The secret data is forming during signing up process and usually consists of username or ID and password.

4.1 WPMSs Features

WPMSs can make the processes of managing projects easier, quicker, and more effective. All management processes from bidding to project completion can be carried out through the system. All projects of an organization are managed from one central and common location that stores all their related-information, and can be accessed anytime and anywhere. The following features are brief examples of many features WPMSs provide for organizations in the construction industry involving all project management processes.

4.1.1 Document management

WPMSs allow project members to store project files and documents for instant access and retrieval at anytime and anywhere. Project members can always find the documents they need immediately and they do not need to transit between sites to get certain documents and files. They can use their PC, iPhone, iPad, etc. to access project files and documents they need online.

4.1.2 Schedule management

WPMSs make the process of scheduling simpler, faster, and focused on the needs of project members. Using online scheduling ensures that the project members use the latest and most up-to-date schedule version, and all project members use the same schedule version at any time. The project members can update and edit the schedule online in real-time and with less time, effort, and cost.

4.1.3 Communications management

WPMSs make the processes of communications and information exchange between project members easy and effective. New project information such as changes to the schedule, revisions, new documents, submittals, approvals, requests, etc. becomes available immediately to project members and they receive automatically notifications and emails whenever any change is made on any item of the project in the system.

4.1.4 Collaboration

WPMSs make working together simpler and more effective. Project members can know what is going on all the time and to work together online in real-time. These systems provide a central and common place for project members to discuss and exchange information online. Discussion Forums and Discussion Boards are widely used in WPMSs and every member of the project team can create a page for discussing some topic or item related to the project with other project members.

4.1.5 Risks and issues management

WPMSs make the processes of managing project risks and issues easy and effective. They provide a systematic procedure for identifying, submitting, assessing, and resolving and closing the risks and issues. Any member of project team (with the appropriate permission) can submit risks or issues online easily and quickly. The project manager and team members can immediately access the details of the submitted risks or issues, and participate in making resolutions anytime and anywhere.

4.1.6 Change management

Project members can quickly and easily manage the project changes using WPMSs. They can manage the changes from request to approval online in real-time. Any member of the project team (with the appropriate permission) can enter the system and submit a request for change anytime and anywhere. The project members can immediately know the information of the submitted changes and make responses to the requests online. When a change is approved, all project members are automatically notified and quickly know the details of the change and its impact on the project timeline, budget, quality, and other project items.

4.1.7 Requests for information (RFIs) and submittals management.

WPMSs provide effective tools for project members to manage the processes of questioning and answering in easy ways. The project members can quickly create and reply to questions about any item related to the project. Electronic documents of any type can be attached to the requests.

4.1.8 Project reports

Project reports are very important part for project managers and members. WPMSs provide real-time status reports of various project items such as project activities and tasks reports, costs and expenses reports, payments reports, resources reports, risks and issues reports, project portfolio reports, etc. Project members can get project status reports quickly at any time and anywhere. Project reports can be viewed online, printed, or exported to the computer.

4.1.9 Meetings management

Meetings are important part of projects. Many decisions and actions related to a project are made during the meetings. WPMSs provide effective tools for managing meetings electronically. Meetings information such as topic, time, attendees, agenda, duration, and location can be quickly created and distributed among meetings members. When a meeting take places, the members can easily create the minutes of the meetings, actions, and share them with project members.

4.1.10 Integration
WPMSs support import and export of project documents and data between these systems and the most common desktop programs used in projects such as Microsoft Office and Microsoft Project, and Adobe Acrobat Reader

4.1.11 Others for instance: bidding management, project team data management, logs and timesheets management, approvals management, project portfolio management, estimating management, video-conferencing, etc.

4.2 WPMSs Types and Solutions
WPMSs can be classified according to the type of development or investment as following:

4.2.1 In-House Completely developed WPMSs
This type is based on developing and operating the system completely by the organization itself. This option enables the construction organizations to make systems that are best fitting and focused on their needs and requirements. They can fully customize the systems and their features to fit their business environments and operational procedures. It is obvious that this type requires lots of investment, outsourcing, and long developing cycle, **Chan** and **Leung, 2004**. Therefore, this option is suitable for the large organizations.

4.2.2 Ready web-based application software packages
This type of investment enables the organization to purchase ready software package and install it on its own servers. This option is chosen by organizations to overcome the process of developing system software and reduce the need for outsourcing and to reduce the life cycle of the system development. Having the software installed on organizations' servers means that the organizations have complete control over the system. However, this option also require high investment and outsourcing (but lower than the first type).

4.2.3 Software as a service (SaaS)
This option is based on renting a completely developed system from IT companies called Application Service Providers (ASPs) for periodic fees (monthly, quarterly, annual, etc.). ASPs are professional IT organizations that develop ready-to-use systems (hosted software). The construction organizations (customers) do not need anything to install on their side (computers or servers) except a web browser and making an account at ASP's to get started, which take a few minutes to be done. The construction organizations can immediately use the service (system) after making the account. This type of systems is characterized by low initial cost (only fees of using the service), reducing much the need for outsourcing and IT experts, and it is the most popular and common type among the three options and suitable for small to medium sized organizations.

4.3 Benefits of WPMSs
There are many benefits these systems can provide for instance the following benefits:

- All information that is related to a project is stored and being available for project members in one common place and can be accessed anytime and anywhere.

- Unifying the source of information for project members, where all project members have the same information at any time.
- The system provides project members with the most current information more quickly and easily.
- All communications, correspondences, and discussions related to a project are carried out through the system, which records comprehensive details for these processes.
- New information such as changes, updates, etc. are spread more quickly and in less time, effort, and costs among project members.
- Improving documentation of projects.
- Improving collaboration, organization, and coordination in projects.
- Improving the knowledge level of project members.
- Improving the quality of information display.
- Organizing the information in an easy manner to be found.

4.4 The Proposed System for Iraqi Construction Organizations

The final goal of the study is to develop the final configuration of the proposed system that best fits the construction companies in the construction sector and to solve or reduce as many as possible the problems, challenges, weaknesses, inefficiencies and inefficacies in the projects. The problem here is how to incorporate WPMS with the organizational structure of the construction organizations and the project site teams to develop an integrated system that can manage the construction project information and communication more effectively and efficiently without conflict of the system with the rules and laws followed in these organizations. The nature of this incorporation determines the manner of information flow in the system because the new system provides more methods and solutions for communicating and managing projects' information between the employees and project team members of the organizations without changing the general procedure followed in the construction organizations.

The organizational structure of most construction organizations consists of the following parts: Board of directors, Departments, and Sections that branch from the departments. The information and documents of the projects pass among these parts until they reach the project site teams throughout the Project Department, which is responsible for managing, controlling and monitoring the project processes, activities and execution, and acts as a connector between the organization parts and the project teams. Most of project information and communication problems happen in the circle that involves the Project Department and project sites because the actual use and implementation of the information happen in this circle. Therefore, and because of making changes in this circle is somewhat easier than making changes in the internal systems of the organizations that are subjected to stronger and a lot of rules and laws, the system will be developed to manage the processes that occur in the circle of Project Department and project sites. The benefits of the new system are not restricted to this circle only, but their effects are reflected on the other parts and the organization generally since the Project Department of any construction organization plays a key role in its projects construction and its success is reflected generally on the organization and its reputation.

However, some suggestions are proposed in the system to improve the performance of information communication among the internal parts of the organizations by connecting them through a local

area network (LAN) besides the traditional (current) system or procedure followed. The local area network can give a lot of support to the processes of information and documents communication among the different parts of the organizations and provide an instant medium for communication and information exchange among organization employees. In addition, a local server can be used to support and increase the performance of the local area network by connecting the local server to the local area network. The local server can be used for storing the information and documents of the projects centrally to provide the possibility of accessing and retrieving them anytime, **Fig. 2** illustrates the final configuration of the proposed system. There are several notes on the figure mentioned:

1) The phrase "Normal Communications" refers to the traditional methods of communication such as face-to-face, phone, email, etc.
2) The direct link between the local server and computer and communications department means that this department has control over the server in terms of administration and maintenance purposes.
3) The red line refers to limited or restricted and secured access.

The local area network can also be connected to Internet (if required) to provide the project members or the employees of an organization with the possibility of accessing their computers and the other machines that are connected to the local area network, and the information and documents that are stored on the local servers anywhere. As results of the great advances in information and communication technology, the local area network can be made to provide many features and benefits that can ease improve and enhance the different processes of information, and communication in the organizations, for example, the following features can be handled by using the local area network:

a) Quick or immediate (on-demand) communication and information exchange among organization members.
b) More effective ways for sharing and transferring information and documents.
c) The possibility of making immediate audio and video communication among organization members.
d) The possibility of sharing applications and machines among organization members.
e) The local area network can be connected to Internet to provide remote access to the local area network and the documents and machines and doing the different operations such transferring files, running applications and connected machines, revising documents, accessing the personal computers, etc.
f) Reducing the other communication methods such as face-to-face, Mobile Phone, email, etc., and the movements between the different parts of the organizations.
g) The local area network can be supported by a local server to provide a central and common repository for the organization information and data.
h) The local area network can be connected to other organizations to share information and other resources, and to make remote training, learning, conferencing, etc. The type of connection depends on the geographic distance between the connected organizations for instance the connection may be using Internet, WAN (Wide Area Network), LAN, etc.

4.5 WPMSs Adoption and Implementation

The process of adopting and implementing WPMS requires following correct and effective procedure in building and applying this system and to transfer from the current state to the new state that the system require. A systematic procedure for helping organizations to build, adopt, and implement system that best satisfies their needs, requirements, and goals is required intensively. Without following the correct and effective way in choosing and applying the system, it is not expected to success or continue using the system and achieve the expected benefits and goals.

5. CONCLUSIONS

The conclusions of the study can be illustrated as following:

- There are a lot of problems, challenges, weaknesses, inefficiencies, and inefficacies that are related to project information and communication management in the construction industry in Iraq, which have great impact on project management, execution and completion.
- The current performance of project management is not satisfactory, and not agreed with the current projects that have more challenges, requirements and expectations, and are larger in number, size and complexity.
- Plenty of challenges and problems that intercept the processes of communication and information exchange among project members.
- Plenty of delays, reworks, and downtimes that due to retardation of communicating or providing information at the right time for project members.
- The level of supporting, training, and developing the skills and knowledge of individuals on using electronic project management techniques and programs is low and does not meet the ambitious and requirements.
- Plenty of time, expenses, and effort are spent on information management and communications during the construction of projects.
- The engineering staffs are not qualified enough with project management.
- Unemployment of the new project management methods and techniques makes one of the most important reasons for low project management performance.
- Weakness and ineffectiveness of the processes of collaboration, organization, and coordination among project members.
- The geographic dispersion of construction project and project members' sites makes one of challenges facing construction projects and information and communication management.
- Weakness of documentation level in projects.
- Insufficiency of the authorities given to project members.
- Insufficiency of laws and legislations.
- The study showed that WPMSs could improve and develop the current performance of project management through improving and enhancing the processes of information and communication management. These systems introduce competitive solutions to the problems, challenges, weaknesses. Inefficiencies and inefficacies related to information and communication management and project management of the construction projects. The many and different solutions that these systems offer for construction organizations make one of the

advantages of these systems. However, understanding the technology is the key for applying these systems successfully and effectively. Following reasonable procedure from preparation and adoption to implementation is very important consideration to ensure choosing best solution based on needs and requirements and to satisfy the goals and expectations

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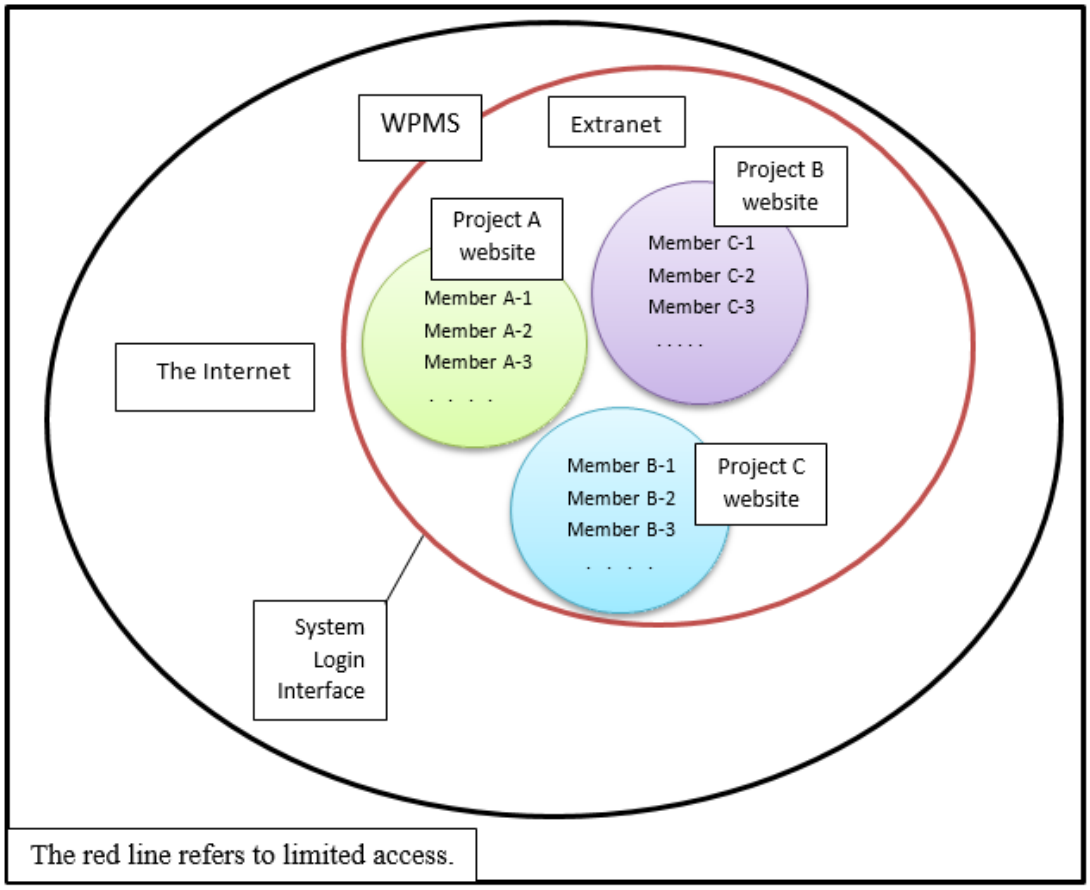

Figure 1. Simple model of web-based project management system.

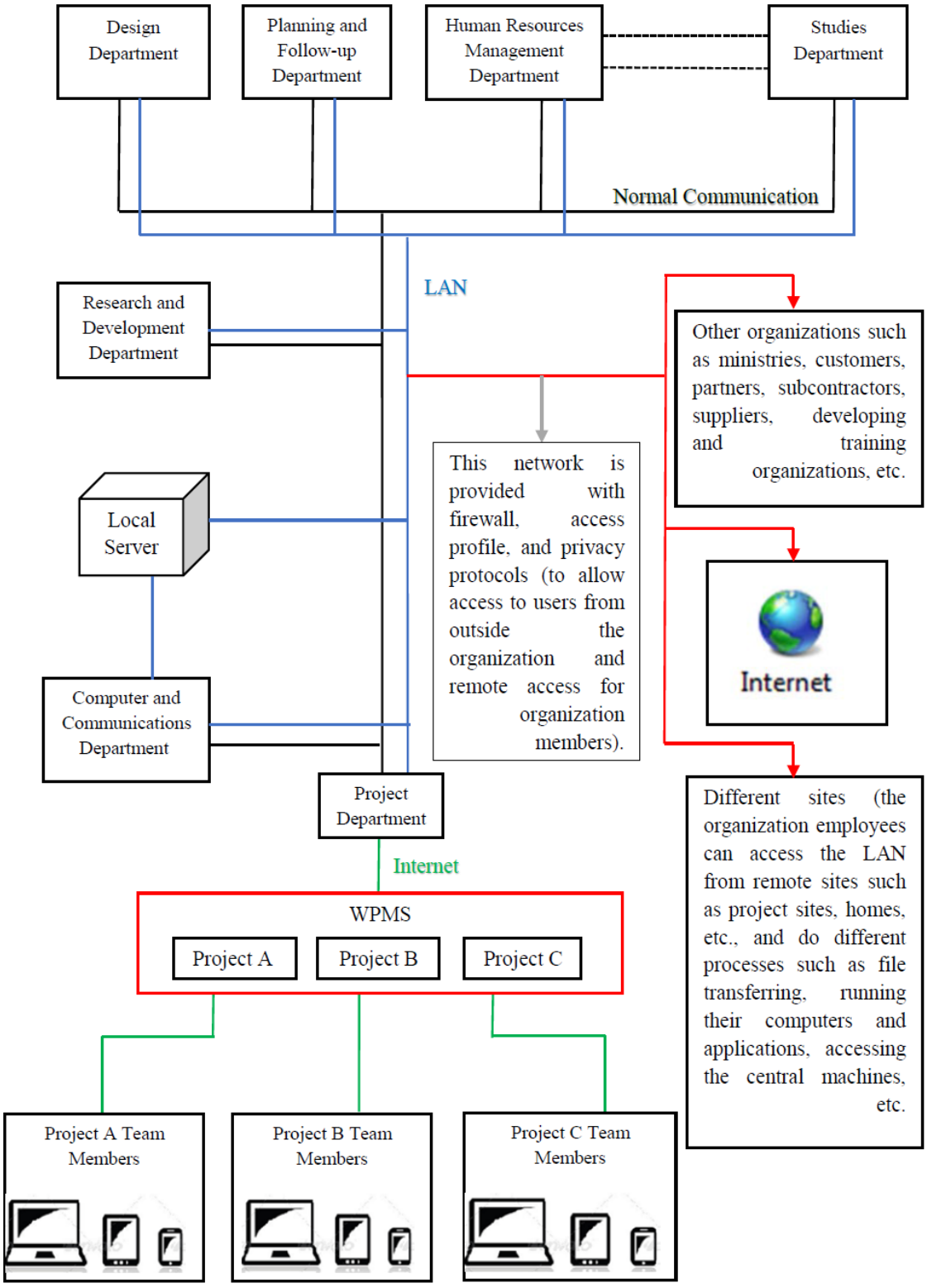

Figure 2. The final configuration of the proposed system.