Collaboration in AEC Design

Web-enabling Applications

using

Peer-to-Peer Office Communicator

Dipl.-Ing. Ulrich Hartmann, Nemetschek Technology GmbH (UHartmann@Nemetschek.de)

Summary

A market analysis conducted by Gartner Dataquest in August 2001 has shown the typical characteristics of the AEC design process. High volatility in membership of AEC design groups and members dispersed over several external offices is the common collaboration scenario. Membership is most times short lived, compared to the overall duration of the process.

A technical solution has to take that into account by making joining and leaving a collaborative work group very easy. The modelling of roles of collaboration between group members must be based on a commonly understood principle like the publisher / subscriber model, where the individual that is responsible for the distribution of vital information is clear.

Security issues and trust in the confidentiality of the system is a central concern for the acceptance of the system. Therefore, keeping the subset of data that will be published under the absolute control of the publisher is a must. This is not the case with server-based scenarios, sometimes even due to psychological reasons.

A loosely bound Peer-to-Peer network offers advantages over a server-based solution, because of less administrative overhead and simple installation procedures. In a peer-to-peer environment, a publish/subscribe role model can be more easily implemented. The publish/subscribe model matches the way AEC processes are modelled in real world scenarios today, where legal proof of information exchange between external offices is of high importance.

Workflow management systems for small to midsize companies of the AEC industry may adopt the peer-to-peer approach to collaboration in the future. Further investigations are being made on the research level (WINDS) by integrating the viewer and redlining application Collaborate! into a collaborative environment.

1 Introduction

The design industry continues to buzz about collaborative engineering and the call for tools to address the needs related to this growing trend. But what is necessary to develop a solution for collaborative engineering ?

Developing and choosing the best collaborative engineering solutions will involve careful consideration of the particular modes of collaboration used in different *types of design* and engineering processes.

A solution has to take into account the organizational and technical infrastructure of all participants in the process. *Volatility and fluctuation* within collaborating groups, as well as *legal proof* of outbound communication has to be seriously considered.

A collaboration platform has to offer the technical flexibility to adjust to customer-specific collaboration environments. However, there is no one-size-fits-all solution across all different design disciplines. Peer-to-Peer Office Communicator focuses on the specifics of collaborative processes in small to midsize companies of the AEC industry.

2 AEC Collaboration

A Market Analysis conducted by Gartner Dataquest in August 2001 has shown that "in the AEC design world, collaboration typically involves the interactions among the architects, building owners, building operators, facilities managers, construction professionals, contractors, civil and structural engineers, and materials suppliers. The AEC design environment is characterized by its reliance on a great many disparate collaborating parties spread across many different organizations." Figure 1 illustrates a typical collaboration scenario for an AEC project. "Virtually every person in the diagram belongs to a separate external organization. The need for collaborative practices to span numerous organizations is vital, but is presently dependent mostly on non-technology-enabled media.

The mode of collaboration today relies on the use of telephones, fax machines, and paper drawings and blueprints that must be couriered between offices. Few collaboration processes utilize modern IT tools to facilitate communications. Additionally, there are few standard tools and practices for storing project data and managing it once the project is completed. Passing along data to the next stage of the building lifecycle is especially important for ongoing facilities management functions. There has historically been no central repository for even any subset of the project data, which include project specifications, CAD drawings, bills of material and project schedules." Another characteristic of AEC projects is that the project participants either do use or expect to be using a fairly wide variety of computing devices in their collaborative work. Being able to share documents from desktop computers to handheld and mobile computing devices will be necessary.

Collaboration solutions will need to take this requirement into consideration in adapting information flows to multiple types of hardware platforms and accommodating both the wireless and wire line transmission of information.

Traditionally medium size companies make up the vast majority of Nemetschek's customers base. Typically, staff members are primarily involved in the design process itself. Administrational overhead of any kind is tried to be put at an absolute minimum. Management of IT resources such as networks, servers and peripherals will be conducted as a subordinate – though necessary and vital– task. This task is often performed by individuals primarily engaged in other duties.

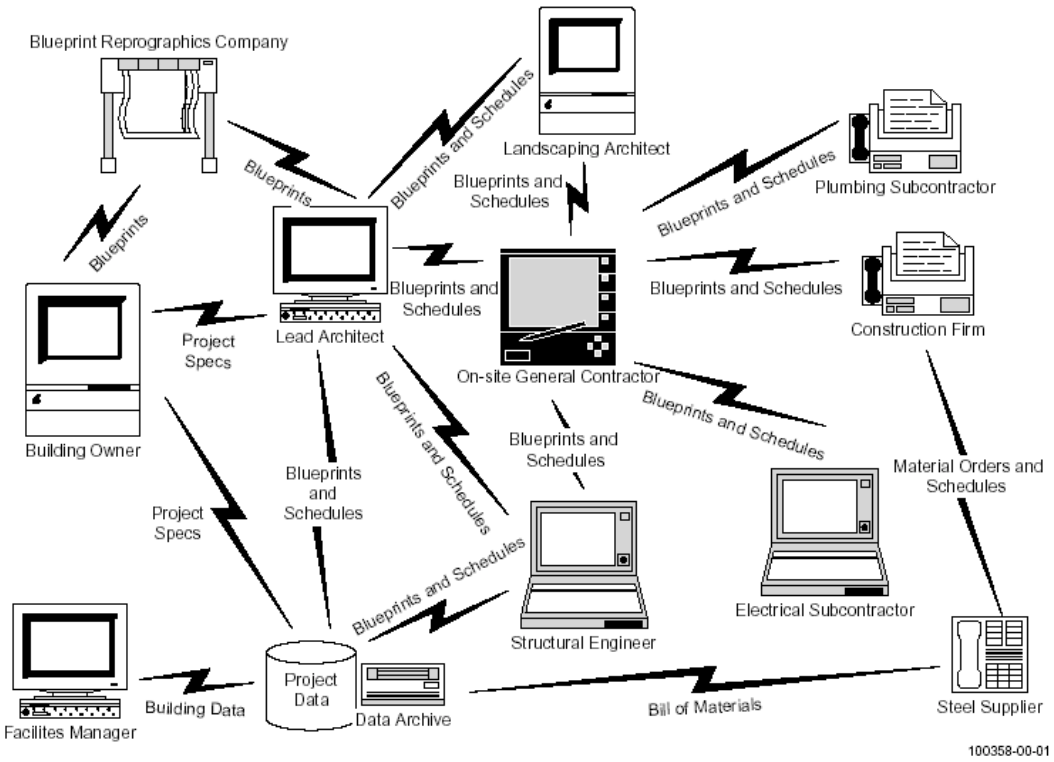


Figure 1: Typical collaboration scenario for an AEC project

3 Added Value of Collaboration

Return of investments that have to be made in order to adopt collaboration techniques in companies will happen only if the processes expected to be optimized are very well understood.

Collaborative design and engineering is about putting pieces together, taking all individual contributions and linking them together into a unified, functioning finished product. It includes tasks such as:

- Interrelation of all unique pieces of the design
- Exchanging information between design project participants
- Making group decisions throughout the project

- Allowing other project members to access relevant project information
- Keeping project members updated on status and other pertinent data on a timely basis

Design teams have gotten bigger and more geographically dispersed, the design cycle time has become more compressed, project deadlines have become less flexible, the amount of overall project data has become unwieldy, and in many cases, the designs themselves are more complex. This increase in collaboration chaos has created an increased need for formal collaboration processes. Collaborative engineering software tools are one key to fill this process void. Project teams will benefit from the process structure that software tools provide to what was formerly an informal collaboration arrangement. Software-based collaboration tools have the potential to help organizations institute efficient design project practices, such as:

- Structuring the interaction between team members
- Providing and tying together applications used in different functional groups within the team
- Documenting and archiving project data and communication
- Managing the flow of information between team members
- Allowing project data to be easily navigated and searchable
- Including all the tools and capabilities necessary for designing

4 System Architecture for AEC Design Processes

In AEC design the relative size of a collaboration team is comparatively high, in contrast to other key design disciplines. The degree of collaboration with external organizations is high. Members of the design team are often globally dispersed. During the design process the membership fluctuation of the collaboration group is relatively high. Members, like planners and experts, are often loosely bound to the project. The diversity of computing platforms and applications used by team members is potentially high.

4.1 Team member interaction characteristics

- More than one single (central) source for project data
- Delegation of tasks to specialists and subcontractors
- Incompatible electronic data
- Legal proof of information delivery and reception
- High bureaucratic overhead for administration of exchanged data
- Information hiding between team members, due to competition considerations

4.2 AEC Collaboration Requirements

An AEC collaboration platform must

- supply a flexible mechanism to manage collaborating groups. User rights, connection establishment, definition of communicated data, media conversion.
- require a low administrative overhead for setting up interaction facilities. Downloadable tools, easy setup.
- allow flexible modeling of roles and data flow in a service-like scenario.
- disperse security reservations by keeping confidential data under the control of its originator.

4.3 Service-like Peer-to-Peer Architecture

Setting up a client/server architecture for collaboration management is commonplace, though not the optimal choice in many cases. Group volatility, distrust against mixing sensitive data on the same server like a competitor, and ease of setup and use are strong arguments for a de-centralized solution.

4.4 Modelling Collaboration Processes as Service Interactions

Recalling Figure 1 (typical collaboration scenario for an AEC project) we can see members of a collaborating group exchanging data back and forth by either being in charge of supplying data on demand or being informed by another member. In terms of process modeling this relationship is called a **Publish/Subscribe** pattern.

4.5 Publish / Subscribe Scenario

In today's real world AEC collaboration scenarios the roles of publishers and subscribers are implicit. Participants may be in charge of passing back drawings or documents to the ordering party on the basis of their role as an expert or subcontractor. Architects or engineering offices act as a switchboard by distributing data to members (publisher role) as well as asking for results on a given task (subscriber role). Only a selected part of data is been actually exchanged. Collaborating members will of course hide sensitive internal information against each other when they are competitors or expect to be competitors in future projects. Collaboration of (potential) competitors is usually the case in AEC projects. Therefore, the solution of security issues is crucial for the acceptance of a collaboration platform. Many centralized platforms have failed due to user distrust in confidentiality of server-based solutions.

Peer-to-Peer Office Communicator makes communication roles explicit by assigning the role of a publisher and/or a subscribers to users. The formal role of a publisher implies the duty of keep

publications up-to-date, the role of a subscriber implies the duty of processing data if required.

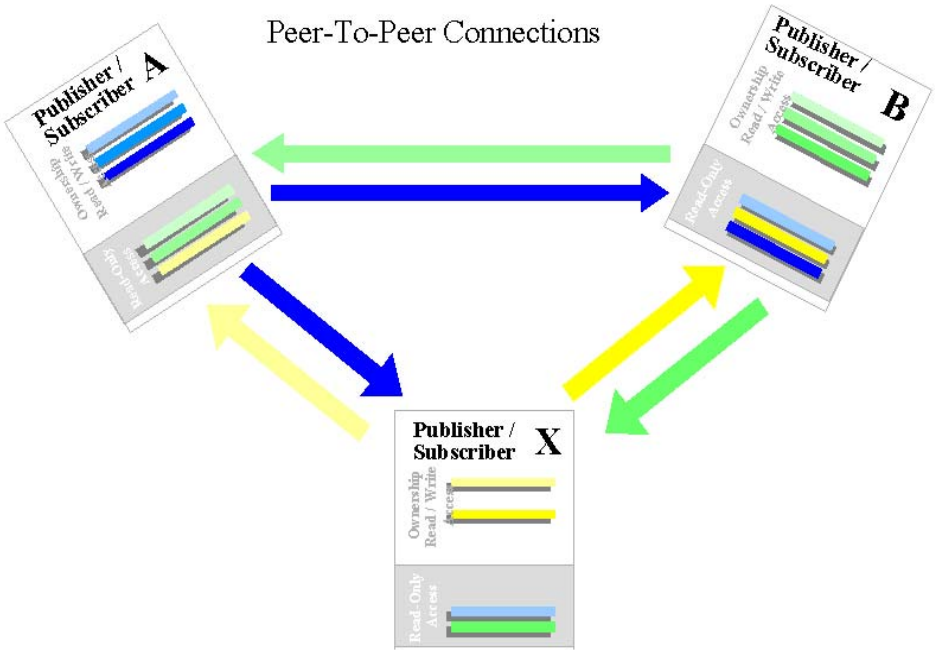


Figure 2: Groups of Publish/Subscribe services in a Peer-to-Peer network

The system supplies a tracking mechanism to guarantee a legally proof of delivery and reception.

4.6 Local Working Copies

One key concern of project data exchange -the loss of control over confidential business data- is addressed by owner-controlled publication management. It lets participants decide which part of their locally owned data will be part of a publication. Figure 3 shows three group members mutually publishing and subscribing project data. Subscribers hold a copy of the original publication. They are free to derive further documents from their local copy or use it unchanged just for their own information.

Like in real world, working on copies implies the occurrence of redundancies. Resolution of redundancies, e.g. by a merging process, can be done only by applying the business rules inherent to the problem. Due to the complexity of AEC design problem, to date only a small set of redundancies can be resolved completely automatic. Most times expert interaction is required. For this an other reasons (legal proof, variant checking, etc.) a collaboration system is backed by a version control system in many cases.

5 Web-Enabling Applications

Peer-to-Peer Office Communicator is a framework that provide collaborative means to applications. In order to collaborate, applications connect to the services of Peer-to-Peer Office Communicator. Those services are

- Peer-to-Peer administrative services
- Peer-to-Peer data exchange
- Peer-to-Peer object delivery service

Connecting to the services is just a technical act. Most important is the semantics of communication between collaborating clients. Applications of same type may communicate with their own proprietary semantics, whereas applications of different type have to agree upon a common semantic. This requires an additional integral step. A common approach is the definition and use of an XML based language, to reach a common ground for information exchange.

5.1 Peer-to-Peer Administrative Services

This service provides the basic functionality for setting up collaborating groups. Group establishment, joining and leaving of group members and maintenance of connections between members is the purpose of this module. On the technical level, several protocols for communication are possible. For internet communication the hypertext transfer protocol and the email protocol is suitable for peer-to-peer communication. The actually used protocol must be transparent to the application that makes use of Peer-to-Peer Office Communicator services. The interfaces between Peer-to-Peer Office Communicator and an application is independent of the actual protocol used for data transfer. Peer-to-Peer Administrative Aervices provide tools for managing technical aspects of communication outside the applications that are using Peer-to-Peer Office Communicator. Different protocol managers can be plugged in and out, making the integrating of further enhancements easy (e.g. .Net Remoting, SOAP, map agents, etc.)

5.2 Peer-to-Peer Data Exchange

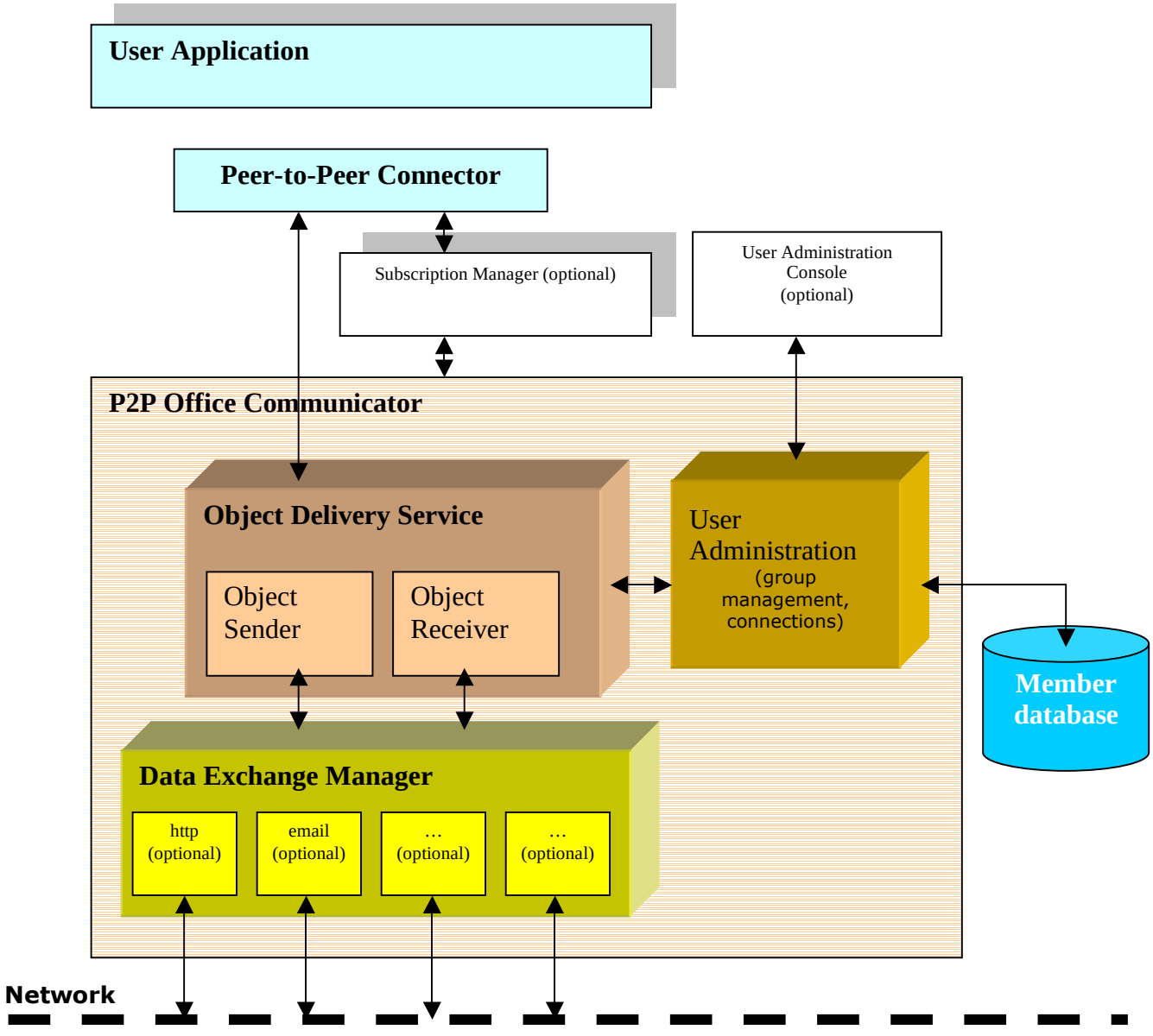
On top of the protocol level applications can exchange data through the network using the already established connection and the collaboration group that have been defined through the administrative services. The peer-to-peer data exchange module delivers data to group members and receives data send in by others. Applications can get (legal) proof of the reception of data by using an acknowledgement mechanism supplied by the Peer-to-Peer data exchange module. The semantics of exchanged data is unknown to the exchange service, only streams of bytes are exchanged on this level.

5.3 Peer-to-Peer object delivery service

This service gives application the ability to exchange objects on a semantical level. Applications may send and receive C++ object as defined in their own proprietary problem domain. This makes the exchange of stateful application data especially easy to handle.

5.4 Applying business rules of communication

The decision which part of application data should be exchanged with outside applications cannot be made by a general service like Peer-to-Peer Office Communicator. Applications willing to use Peer-to-Peer Office Communicator services have to create a 'Peer-to-Peer connector' in order to apply their own rules to information exchange.



Applications using Peer-to-Peer Office Communicator

5.5 Workflow Management System

A LAN-based AEC workflow management system may already provide its functionality inside offices of the AEC design industry. In order to exceed LAN boundaries to integrate external offices into workflow processes a prototype Peer-to-Peer Connector object has been implemented. The connector object implements the communication rules that are specific to the workflow management system.

Due to the process-oriented nature of workflow systems, process data has to be exchanged through a previously defined protocol. Typical objects in a workflow management systems object model are

- Processes
- Task
- Actor
- Action
- Document

Actions performed by actors imply the use of tools (programs) in order to fulfill a task. Tools operate on documents which are contained in files.

The following protocol for communication has been defined and implemented (prototype):

Step 1: Authentification

Before a communication link can be established, users that are authorized for exchanging data between offices have to be defined on both systems. These users obey to a special role in the workflow management system. Unauthorized communication requests will be ignored. In case of an authorized request the project in which the sender is considered a valid user will be opened.

Step 2: Collaborative Project Definition

Authorized users have to agree upon which project to collaborate, since the workflow management system handles a multitude of projects that may or may not be open for external communication. For that reason that initiating client sends a project list validation request to the remote client. The target client has to agree to open the specified project for external communication.

Step 3: Task data exchange

After agreeing on the collaborative project the actual task data has to be exchanged. This is done by sending the respective documents to the remote client, using the Peer-to-Peer Office Communicator Object Delivery Service.

The task can now be processed in the remote system in the usual fashion. After task completion data exchange has to take place in the rear direction. In principal, step 1 through 3 have to be performed with initiator and remote client switched.

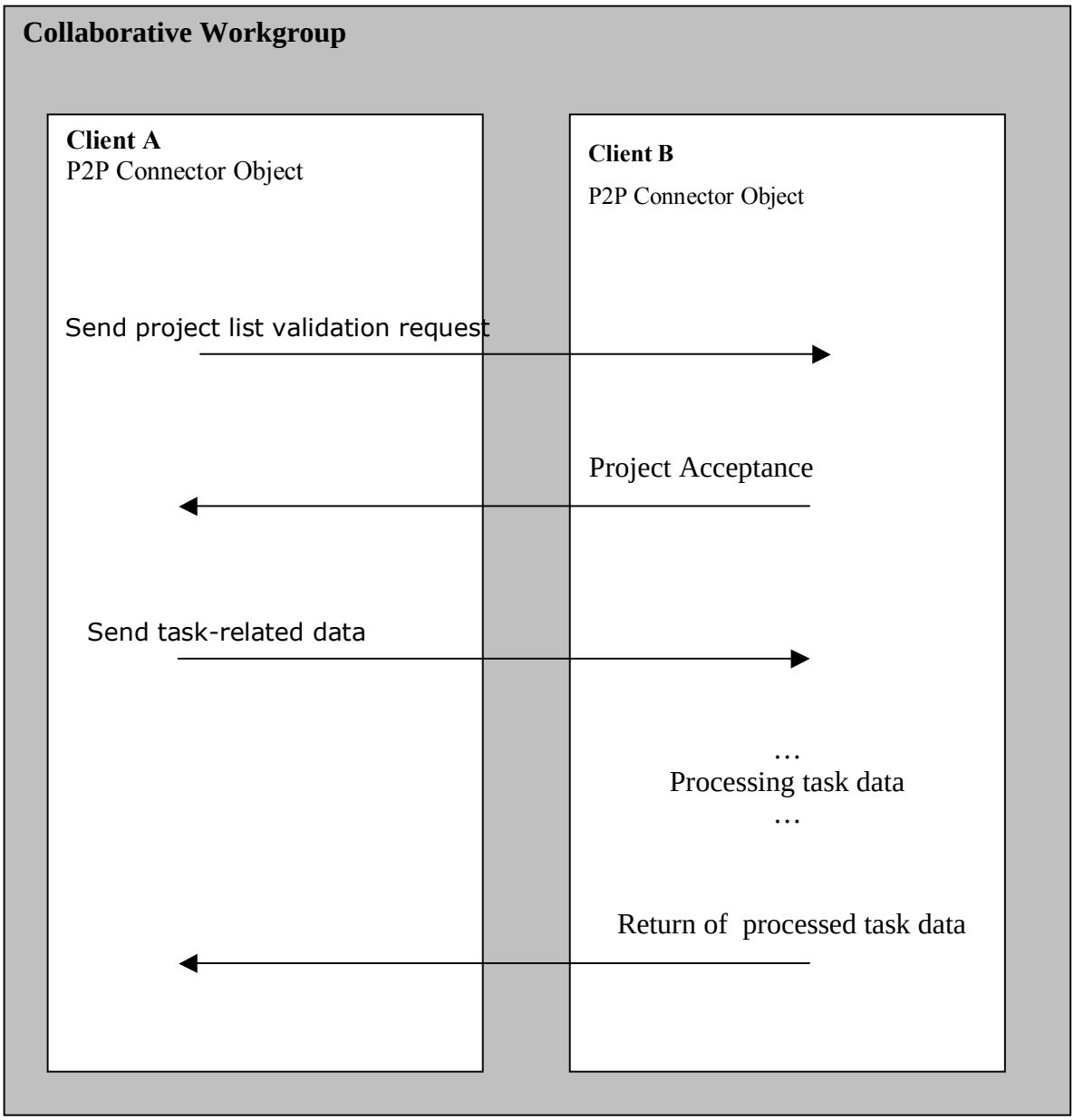


Figure 5: inter client communication protocol

5.6 Publish / Subscribe services

In AEC design processes many dependencies exist in a mulitlateral manner. An obvious example is the influence of structural changes on overall building costs. Engineers who ask for structural changes are not in charge of cost management. Re-checking the effect on costs is managed elsewhere in the process.

Explicitly modeling the dependencies by applying a publisher and a subscriber role to project data makes failure in information propagation unlikely.

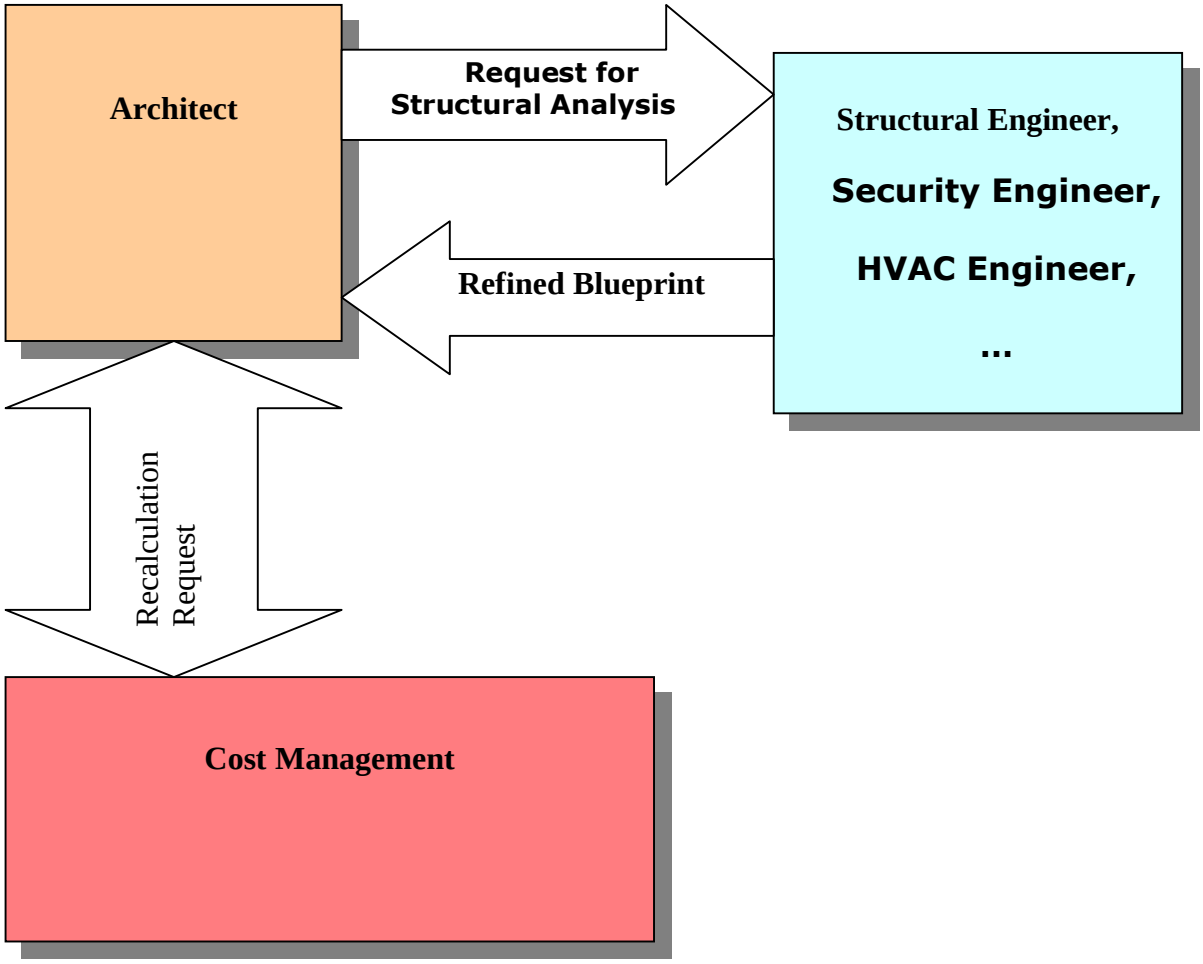


Figure 6: Explicit modeling of dependencies for cost control

As shown in figure 6, an architect who gives a basic blueprint to an engineer for further refinement, will have to re-check the follow up effects of the result due several other conditions, e.g. cost control. If the cost control unit subscribes to the same document that the architect has given to the structural engineer, it will automatically be informed of relevant changes.

By defining roles explicitly, it is made clear who is in charge of sending information (publisher) and who is dependent on getting information (subscriber). Formally modeling those roles will not only streamline the overall design process, it is also of legal importance, taking into account that in the AEC design process many external contractors are generally working together.