Chapter 1

Introduction

1.1 General Concept

Teleteaching is regarded as the process of learning with the use of telematics, that is, the combination of telecommunication, information and multimedia technology and its services.

In such a scenario:

- All the interactions among student, teacher and instructional material, which are essential for the instructional process, can be implemented.

- The information and knowledge, which are essential for the instructional process, are accessible and readable.

- The place, time and the pace of learning are flexible.

Teleteaching application on IP network uses video conferencing, which is live audio/video communication among a group of geographically dispersed users. The video conference combines the transmission of video screens with high quality audio to provide communication facilities to a group of users. Video conferencing is impressive, because it
has advantages, like visual communication and the capability of attending lesson from distant locations. To support Teleteaching services either a point-to-point video conference (there are only two participating points in the Teleteaching lesson), or a multipoint video conference (more than two participating points) are used. Multipoint videoconferencing uses special equipment, called a multipoint control unit (MCU).

The Internet Protocol (IP) is the network protocol of the Internet. Data transmission in IP is connectionless, which means that packets from the same end-to-end packet flow are treated independently and may traverse different routes through the network. A connectionless data transfer mode is lightweight as no connection establishment is necessary. IP has a powerful mechanism, called IP Multicast, for conducting multipoint-to-multipoint communications. The Multicast Backbone (MBONE) [133, 134] has been offering an IP Multicast service on the Internet for low-bandwidth audio/video conferences since 1992. Based on the recent ITU-T H.323 standard [116], products for high-bandwidth video multipoint applications over IP Multicast are emerging [90]. Figure 1.1 displays the architecture of the multipoint Teleteaching scenario with the use of IP network. This scenario uses the ITU H.323 standard. This scenario has special equipment, a MCU (Multipoint Control Unit), acting like a reflector. The MCU collects the audio/video of all the participants and transmit to the participant only one audio/video at a time, mostly the video of teacher during Teleteaching.

The work proposes to focus mainly on the development of conceptual level design method of Teleteaching System. It considers a well formed specification of the user requirements as a first task to initiate the conceptual level of Teleteaching System design. After the conceptual design, at the implementation stage some well defined problems of this area are handled in this dissertation work.

1.2 Motivation of the Work

A successful and user friendly design of information system depends on the proper assessment of user’s needs and requirements. Hence understanding of those requirements is of utmost prerequisite for success of interactive system. As specified in the ISO 13407
standard (ISO, 1999), user-centered design begins with a thorough understanding of the needs and requirements of the users. The benefits can include increased productivity, enhanced quality of work, reductions in support and training costs, and improved user satisfaction.

This work envisages a formal specification for goal oriented requirement analysis of Teleteaching System for the above purposes.

For effective implementation of a Teleteaching System, there should be a formal design model of Teleteaching System, where the user level and the system level requirements can be mapped. Teleteaching System is a complex multimedia collaboration activity between distributed set of students and teacher. These requirements originates for the effort to emulate the real world face to face classroom teaching. Some of the following functionalities should be modeled in the design phase of Teleteaching System.
• Interaction: Synchronous interactions between students and teacher. Asynchronous
interactions between student and teacher. Asynchronous interaction between stu-
dent and system.

• Teleteaching session control: Some researchers define the session control by some
control functionalities like Open, Close, Create, Join, Leave, Allow to talk.

• Conference wide resource management: Conference wide resource management is
necessitated as there must be some mechanism to resolve conflicts among partici-
pants (teacher/ student) request for shared resources in telelecture context.

The implementation of a formal model of Teleteaching System corresponds to the
actual system. Many researchers have pointed out a number of difficulties at the time of
implementing multimedia collaboration in IP network. Out of the different synchroniza-
tion issues, Interactive Group Synchronization and Multipoint synchronization are very
important.

Interactive Group Synchronization can be seen as multiple user’s synchronization.
This synchronization task aims at removing semantics incoherence in the dialogue among
all users. This situation happens when a large number of distributed nodes participate in
a lecture session and more than one audio streams generate from more than one nodes at
the same time and reach the mix streams to the listener’s node. In this situation audio
streams become a non understandable one. So audio stream generated at different nodes
must be synchronized with each other.

Multipoint Synchronization involves the synchronization of the play-out processes of
same streams to different receivers at the same time to present fairness to each receiver.
This synchronization is required in case of teleteaching application where a teacher can
send a video sequence (documentary or filmstored content stream) and make occasional
comments about the video simultaneously. Network quizzes is another example. In this
case the same multimedia question must be presented at the same time to all the par-
ticipants to guarantee fair play. In the first example, a simultaneous play out of the
streams are important for both stored content and live content streams. Even the sent
video stream (documentary or film), each video MDU (frame) in multicasting scenario
should be played simultaneously to all the receivers (students) so that the students will have scope to comment and share on the video content with other students.

### 1.3 Organization of the Thesis

With the aforementioned objectives, the thesis has been organized into eight chapters (Including this). The Chapter 4 to Chapter 7 contain the main contributions of this thesis. The brief overviews (shown in figure 1.2) of the subsequent chapters are as follows.

![Thesis Overview Diagram](image)

Figure 1.2: Thesis Overview

In Chapter 2, detail reviews on VoIP based Teleteaching system are presented in mainly four areas namely general reviews of different protocols for VoIP based applications, requirements analysis, conceptual design and synchronization issues. The chapter includes the detailed review of number of protocols for different VoIP based applications. Different approaches for requirements analysis like function oriented requirement analysis, object oriented requirement analysis and goal oriented requirement analysis and a number of formal tools like syntactic theory, HPrTN, conceptual graph, ontology for system design are discussed. Besides the reviews on requirement analysis and system design, reviews on two different synchronization issues on VoIP based Teleteaching system are described. Finally the chapter includes the description of existing formal tools like FSM,

Chapter 3 is about the scope of the work and major contribution of this thesis work. The scope of the work has been drawn from above said objectives and the related studies.

In Chapter 4, a requirements analysis and conceptual graph based requirements specification framework has been proposed for VoIP based Teleteaching system. The proposed framework is based on concept of ontological hierarchy of Teleteaching system. Here goal oriented requirements analysis is used. Initially basic goals of the system are mapped in i* diagram for early requirement analysis. In the next step an extension version of Means End Analysis is used to describe the procedure to achieve the goals defined in i* diagram. An algorithm is designed to convert the Means End Graph to CG (Conceptual Graph). Finally the SRS document of the system is presented in CG named as RCG (Requirement Conceptual Graph).

A conceptual graph based system design and its verification for Teleteaching system is shown in chapter 5. The SRS document found in chapter 4 is used as input to the system design and its verification phase in this chapter. Different modules of the system are designed using syntactic theory with concepts found from the ontology of Teleteaching hierarchy. Then the modules are merged together to form a single module and is expressed in the form CG namely DCG (Design Conceptual Graph). Finally a design verification framework and its metric are presented by which DCG and RCG are compared.

In chapter 6, a synchronization issue namely Interactive Group Synchronization in Teleteaching system is addressed. This synchronization task aims to avoid semantic incoherence in the dialogue between all users. Initially the problem is modeled with the extension of Coloured Petri Net (CPN) by introducing the time parameter in it namely Time Colored Petri Net (TCPN). The proposed model is checked for its correctness by three lemma: Safety, Liveness, Reachability. Finally an algorithm is presented for resolving the Interactive Group Synchronization problem arising out of VoIP based tele lecture system.

Apart from the above synchronization issue discussed in chapter 6, another synchro-
nization issue namely Multipoint Synchronization issue is addressed in chapter 7. This refers to the playout of same media stream to all the receivers at the same time in multicasting scenario to present fairness to each receiver in VoIP based lecture session. To model this issue with the help of existing petri nets some shortcomings are observed. An extended form of petri net namely Self Modifying Stochastic Coloured Petri Net (SMSCPN) is proposed to redress the insufficiencies. This synchronization issue is modelled with SMSCPN and performance level of the model is checked by analyzing the value of two quality metrics Loss Metric and Asynchrony Metric.

In chapter 8, the dissertation ends with a note of conclusion.