BG Pulse Journal
ISSN:19 http://www.bgpulseusa.com/index
BG PULSE JOURNAL

DEVELOPMENT OF A BLOCK DIAGRAM OF A VIRTUAL LABORATORY COMPLEX FOR CLINICAL ENGINEERING

Turdimukhammad Tusmatov G'ofurovich
Andijan State Medical Institute, Andijan, Uzbekistan
doi:https://doi.org/10.5281/zenodo.23577398

Abstract. Training clinical engineers requires practical work with medical equipment, but real devices are expensive, limited in number and risky to use for fault-finding exercises. A virtual laboratory complex solves this by combining software models of medical devices with a small set of real measuring equipment. This article presents the block diagram and room layout of such a complex developed at Andijan State Medical Institute. The complex includes a head computer (server of virtual laboratory works), six student workstations, an electronics engineer's workstation with measuring instruments and two large display monitors, linked by a local network. The block diagram defines the data flows between these blocks: distribution of laboratory tasks and device models, collection of results, demonstration on large monitors and connection of virtual exercises with real measurements. The proposed structure can be used as a model for equipping clinical engineering laboratories in medical universities.

Keywords: clinical engineering, virtual laboratory, block diagram, medical equipment, biomedical engineering education, local area network, simulation.

1. Introduction

Clinical engineering covers the selection, installation, maintenance and safe use of medical equipment in healthcare facilities. Specialists in this field must understand how devices work, measure their signals and find faults. Such skills are formed mainly through practical laboratory work.

Real medical devices are costly, and a university can rarely provide one device per student. Deliberately creating faults in working equipment is also unsafe and can damage it. Virtual laboratories address these problems: software models reproduce the structure and behaviour of devices, while students practise measurements and troubleshooting without risk [1, 2]. Reviews of technology-enhanced and simulation-based education show that this approach improves knowledge and skills [3, 4].

A virtual laboratory is effective only when its hardware, software and room layout form one system. The aim of this work is to develop a block diagram of a virtual laboratory complex for clinical engineering at Andijan State Medical Institute and to define the function of each block and the data flows between them.

2. Materials and methods

The object of the study was the clinical engineering laboratory room of Andijan State Medical Institute. The authors first drew the floor plan of the room (Figure 1) and then derived from it the

functional block diagram of the complex (Figure 2). The floor plan fixes where each device stands and how the network cable runs; the block diagram shows what each block does and which data pass between blocks.

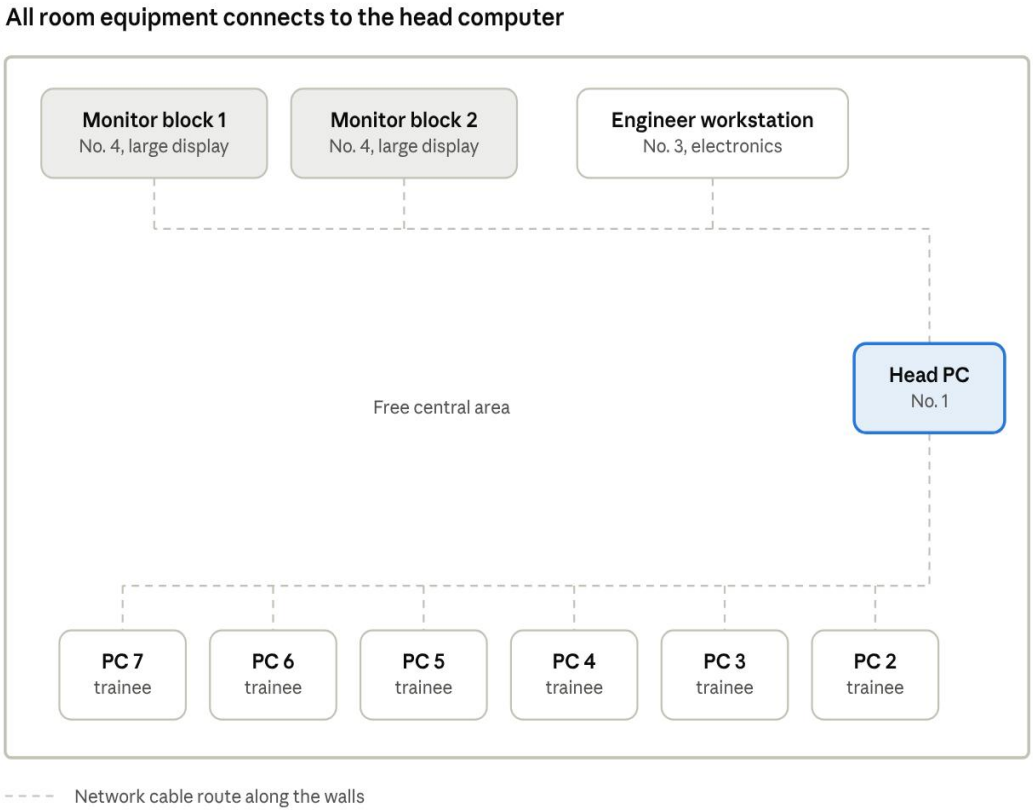


Figure 1. Floor plan of the laboratory: monitor blocks and the engineer's workstation on the front wall, the head computer on the side wall, six student workstations along the back wall; the dashed cable route links them all to the head computer.

The complex consists of four functional blocks (Table 1).

Table 1. Functional blocks of the complex

No.	Block	Quantity	Function in the virtual laboratory
1	Head computer (server)	1	Stores device models and laboratory works, assigns tasks, collects and evaluates results
2	Student workstations	6 (No. 2–7)	Perform virtual laboratory works on models of medical devices
3	Electronics engineer's workstation	1	Real measuring instruments and device modules; links virtual exercises with physical measurements; maintenance of the complex
4	Large display monitors	2 blocks	Demonstrate device models, the instructor's screen and student results to the group

Placement follows the functions: the head computer on the side wall gives the instructor a view of all workstations and monitors; the student workstations stand in one row; the monitors and the engineer's workstation share the front wall. A network switch at the head computer joins all blocks into a star-type local network, while the cable itself runs along the walls in a cable channel.

3. Results

The developed block diagram (Figure 2) places the head computer at the centre of the complex; every other block exchanges data only through it.

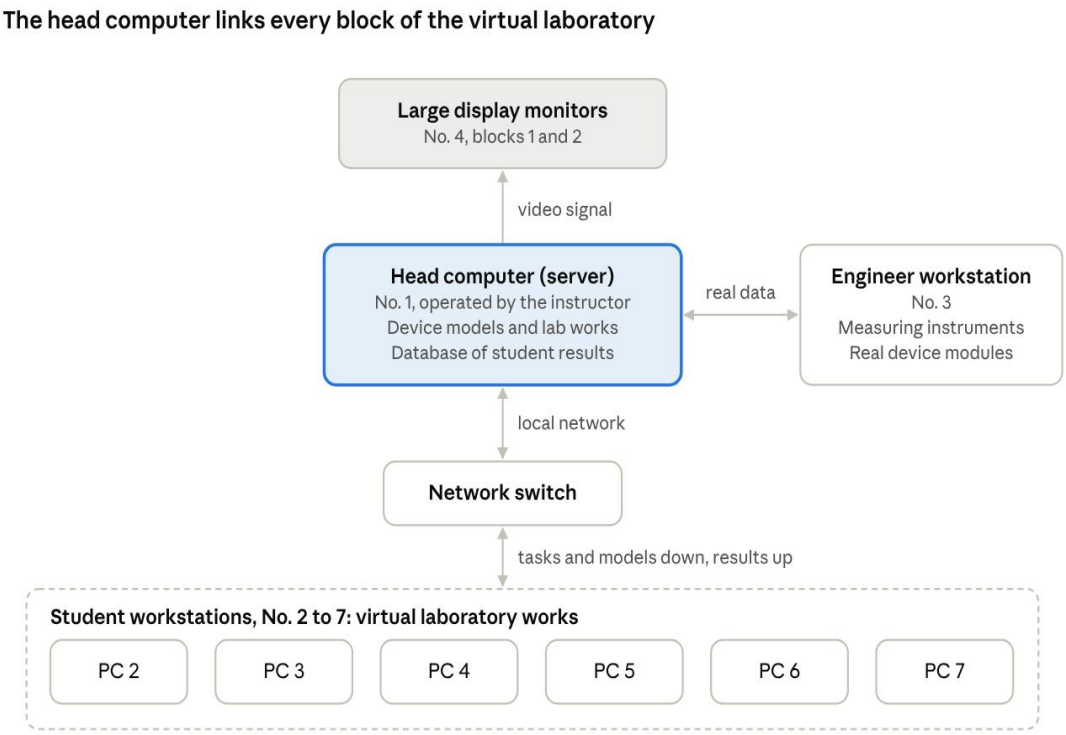


Figure 2. Block diagram of the virtual laboratory complex for clinical engineering.

Head computer (1). It works as the server of the virtual laboratory. It holds the library of virtual models of medical devices, the descriptions of laboratory works and the database of student results. The instructor uses it to assign a work to each student, introduce faults into a device model and check reports.

Student workstations (2–7). Each workstation receives a laboratory task and a device model from the server. The student studies the device structure, takes virtual measurements of its signals and searches for the introduced fault. Measurements and answers are returned to the server for evaluation.

Electronics engineer's workstation (3). This block connects the virtual part of the complex with real equipment. It holds measuring instruments and device modules on which students repeat selected measurements after the virtual exercise. Results of real measurements are entered into the server, so virtual and physical data can be compared. The engineer also maintains the computers and the network.

Large display monitors (4). The server sends the video signal to two monitor blocks. They show a device model during the explanation of a new work and any student's screen during the joint analysis of results.

Order of work. A laboratory session follows the data flows of the diagram: (1) the server sends tasks and models to the workstations; (2) the instructor explains the work on the large monitors; (3) students perform virtual measurements and fault-finding; (4) selected measurements are repeated on real equipment at the engineer's workstation; (5) all results return to the server for evaluation and joint discussion.

4. Discussion

The main advantage of the developed structure is that six students can work at once on models of devices that the university may have in only one copy, or not at all. Faults are introduced into the model, not into real equipment, so troubleshooting can be practised repeatedly and safely. This matches the conclusion of earlier reviews that virtual and physical laboratories complement each other [1, 2].

The second advantage is the link with real equipment through the engineer's workstation. Purely virtual training does not teach how to handle instruments, connect probes or read real signals with noise. Repeating key measurements on real modules closes this gap and lets the instructor compare virtual and real results, which is essential for clinical engineering practice [5].

The structure also has limits. All blocks depend on the head computer, so its failure stops the whole laboratory; a backup of models and results is required. The engineer's workstation serves one student at a time, which limits the real-equipment part of each session. Adding new device models and extra workstations will require more server capacity and network ports.

5. Conclusion

A block diagram of a virtual laboratory complex for clinical engineering was developed. It consists of four blocks: a head computer acting as the server of virtual laboratory works, six student workstations, an electronics engineer's workstation with real measuring equipment and two large display monitors, joined by a star-type local network. The diagram defines the function of each block and the data flows between them and can serve as a model for equipping clinical engineering laboratories in medical universities of Uzbekistan.

References

1. Кобулова, М. А. (2024). Информационные технологии в медицинском образовании-как фактор повышения качества обучения. AndMI Xalqaro ilmiy-amaliy konferensiyalari, 1(1), 434-437.
2. Тешабоева, З. Т., & Кобулова, М. А. (2024). Совершенствование методов привлечения студентов к науке и исследованиям в ВУЗах. Science and innovation, 3(Special Issue 15), 442-444.
3. Кобулова Мохинабону Авазбековна (2024). ОСНОВНЫЕ НАПРАВЛЕНИЯ ИСПОЛЬЗОВАНИЯ КОМПЬЮТЕРНЫХ ТЕХНОЛОГИЙ В АДАПТИВНЫХ ОНЛАЙН ОБУЧАЮЩИХ СИСТЕМАХ. Universum: психология и образование, (10 (124)), 14-16.

4. de Jong T., Linn M.C., Zacharia Z.C. Physical and virtual laboratories in science and engineering education. Science. 2013;340(6130):305–308.
5. Potkonjak V., Gardner M., Callaghan V., et al. Virtual laboratories for education in science, technology, and engineering: a review. Computers & Education. 2016;95:309–327.
6. Cook D.A., Hatala R., Brydges R., et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA. 2011;306(9):978–988.
7. McGaghie W.C., Issenberg S.B., Petrusa E.R., Scalese R.J. A critical review of simulation-based medical education research: 2003–2009. Medical Education. 2010;44(1):50–63.
8. Dyro J.F. (ed.) Clinical Engineering Handbook. Burlington: Elsevier Academic Press; 2004.
9. O'rmonovna X. X. MODERN TEACHING REQUIREMENTS OF THE SUBJECT "INFORMATION TECHNOLOGY IN MEDICINE" //ОБРАЗОВАНИЕ НАУКА И ИННОВАЦИОННЫЕ ИДЕИ В МИРЕ. – 2025. – Т. 82. – №. 2. – С. 98-102.
10. O'rmonovna X. X. TEACHING METHODOLOGY OF INFORMATION TECHNOLOGIES AND MATHEMATICAL MODELING OF PROCESSES BASED ON A CREATIVE APPROACH //ОБРАЗОВАНИЕ НАУКА И ИННОВАЦИОННЫЕ ИДЕИ В МИРЕ. – 2025. – Т. 82. – №. 2. – С. 71-76.