



Warsaw University of Technology

Faculty of Mathematics and Information Science

Bachelor's diploma thesis

in the field of study Computer Science and Information Systems

Design and Implementation of a Collaborative Board Using the
Local-First Approach

Piotr Jankiewicz

student record book number 288767

thesis supervisor
dr inż. Paweł Kotowski

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Abstract

Design and Implementation of a Collaborative Board Using the Local-First Approach

The purpose of this thesis is to design and implement a collaborative board using the local-first approach. The solution uses distributed conflict free replicated data types (CRDTs) and real-time communication via WebRTC protocol to bring effortless collaboration with other users.

Final result of the effort done is an desktop application that enables drawing and erasing on the whiteboard with mutiple users simultaneously. This paper covers description of solution, but also thouches broader topic of local-first application design architectures.

Key words: rust language, local-first, CRDT, WebRTC, distributed system, star topology, multithread real time communication

Streszczenie

Projekt i wdrożenie kolaboratywnej tablicy z wykorzystaniem podejścia „local-first”

Celem pracy inżynierskiej jest zaprojektowanie i implementacja kolaboratywnej tablicy z wykorzystaniem podejścia "local-first". Wypracowane rozwiązanie uzywa rozproszonego bezkonfliktowego typu danych (CRDTs) oraz komunikacji w czasie rzeczywistym przez protokół Webrtc by umożliwić bezproblemową kolaborację z innymi użytkownikami. Ostatecznym wynikiem jest aplikacja desktopowa umożliwiająca rysowanie oraz zmazywanie poprzednich pociągnięć na białej tablicy z wieloma użytkownikami jednocześnie. Praca pokrywa opis rozwiązania ale również porusza bardziej obszerny temat architektur typu local-first w aplikacjach kolaboratywnych.

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1. Introduction

What is the thesis about? What is the content of it? What is the Author's contribution to it?

WARNING! In a diploma thesis which is a team project: Description of the work division in the team, including the scope of each co-author's contribution to the practical part (Team Programming Project) and the descriptive part of the diploma thesis.

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2. Example chapter

This T_EX file is to be compiled with pdfLaTeX (it's just quick build in TeXMaker).

2.1. Example section

Definition 2.1 (Definition). A *definition* is a statement of the meaning of a term (a word, phrase, or other set of symbols).

2.1.1. Example subsection

It's the deepest depth of sectioning allowed by rector.

Definition 2.2 (Equation). In mathematics, an *equation* is a statement of an equality containing one or more variables.

Example 2.3. This is an example of an equation:

$$2 + 2 = 4. \quad (2.1)$$

Equation without a number:

$$2 + 2 = 4,$$

or:

$$2 + 2 = 4.$$

It is worthwhile to peruse other mathematical environments like *multiline*, *align* and their versions with a star (, i.e. without numeration). The description of their use can be found at <https://texdoc.org/serve/amsldoc.pdf/0> starting from the end of the third page.

Equation (2.2) is false. References (and some other things) work properly after compiling T_EX file twice.

$$\int_0^1 x \, dx = \frac{3}{2}. \quad (2.2)$$

Theorem 2.4 is a very interesting result.

Theorem 2.4 (Pythagoras' Theorem). Let c represent the length of the hypotenuse and a and b the lengths of the triangle's other two sides. Then:

$$a^2 + b^2 = c^2.$$

Proof. The proof has been presented in [1] and [2]. We can write then [1, 2]. \square

Corollary 2.5. The use of the term *corollary*, rather than *proposition* or *theorem*, is intrinsically subjective.

Remark 2.6. You can find a rather comprehensive list of available symbols at https://www3.nd.edu/~nmark/UsefulFacts/LaTeX_symbols.pdf.

If you want to find a symbol by its shape, you can use the following site: <https://detexify.kirelabs.org/classify.html>.

Lemma 2.7 (Someone's Lemma). Ten lemat jest nie na temat.

Proof. Dowód przez indukcję. \square

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2.2. Floats – tables and figures

Place labels after captions or you get the wrong labelling.

In Table 2.1 there are additional options for `table` and `figure` environments.

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Table 2.1: Additional options

symbol	effect
h	Place the float here, i.e., approximately at the same point it occurs in the source text (however, not exactly at the spot)
t	Position at the top of the page
b	Position at the bottom of the page
p	Put on a special page for floats only
!	Override internal parameters LaTeX uses for determining "good" float positions
H	Places the float at precisely the location in the L<small>A</small>T<small>E</small>X code. Requires the float package,[1] i.e., <code>\usepackage{float}</code> . This is somewhat equivalent to <code>!ht</code> .

Figure 2.1: Example figure – it has been drawn by **LATEX** default tools

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3. The next chapter

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3.1. Matrices

Simple matrix:

$$\begin{array}{cccc} a & b & c & d \\ d & e & f & g \\ 1 & 1 & 1 & 1 \end{array}$$

Matrix with parentheses:

$$A = \begin{pmatrix} a & b & c & d \\ d & e & f & g \\ 1 & 1 & 1 & 1 \end{pmatrix}$$

Matrix with brackets:

$$\begin{bmatrix} a & b & c & d \\ d & e & f & g \\ 1 & 1 & 1 & 1 \end{bmatrix}$$

You can also use more general environment:

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Matrix with braces:

$$\left\{ \begin{array}{ccc} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{array} \right\}$$

Definition 3.1. Let $A \neq \emptyset$, $n \in \mathbb{N}$. Every function $f: A^n \rightarrow A$ is called an *n-ary operation* or *działaniem określonym na A*. 0-ary operations are constant functions.

Definition 3.2 (Algebra). The ordered pair (A, F) , where $A \neq \emptyset$ is a set and F is a family of operations defined on A , shall be called an *algebra* (or *F-algebra*). The set A is called *the set of elements, support or universe* of an algebra (A, F) and F is called *the set of elementary operations*.

Proposition 3.3. I state that, having passed to the limit, the only thing left me is to camp at said limit or return, or, maybe, search for a pass or an exit to other areas.

Bibliography

- [1] A. Author, *Title of a book*, Publisher, year, page–page.
- [2] J. Bobkowski, S. Dobkowski, Title of an article, *Magazine X, No. 7*, year, PAGE–PAGE.
- [3] C. Brink, Power structures, *Algebra Universalis* 30(2), 1993, 177–216.
- [4] F. Burris, H. P. Sankappanavar, *A Course of Universal Algebra*, Springer-Verlag, New York, 1981.

List of symbols and abbreviations

nzw. nadzwyczajny

* star operator

~ tilde

If you don't need it, delete it.

List of Figures

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If you don't need it, delete it.

Spis tabel

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List of appendices

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2. Appendix 2
3. In case of no appendices, delete this part.