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FORMAL TECHNIQUES  
FOR SYNCHRONIZED  
FAULT-TOLERANT  
SYSTEMS

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Abstract

We present the formal verification of synchronizing aspects of the Reliable Computing Platform (RCP), a fault-tolerant computing system for digital flight control applications. The RCP uses NMR-style redundancy to mask faults and internal majority voting to purge the effects of transient faults. The system design has been formally specified and verified using the EHM verification system. Our formalization is based on an extended state machine model incorporating snapshots of local processors' clocks.

C. E. Landwehr et al. (eds.), *Dependable Computing for Critical Applications 3*  
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Example of a lab abstract. Physics abstract example.

A science lab report is a structured way of communicating the outcomes of your practical work.The structure of a typical lab report includes the following sections:Aim and Hypothesis - Why you conducted the practical work.Method - How you conducted the practical work and how any data processed.Results - What was the data, process or product obtained from the practical work.Discussion - How your results addressed your aim and hypothesis.Conclusion - What was the overall outcome of your practical wok and how do your finding relate to the larger body of scientific knowledge.You can apply the common report writing techniques outlined below, after always checking the specific details of your assignment. Check for discipline-specific requirements. Lab reports can vary in length and format. These range from a form to fill in and submit before leaving the lab, to a formal written report. Keep notes in a dedicated lab notebook. Please note that many units require students to record notes and observations in logbooks in the laboratory. These have their own purpose and conventions and are different from lab reports.Do not copy material directly from your lab instructions. Lab instructions provided by your teachers are NOT in the style of a laboratory report. Use a passive voice in your writing. This means writing in the third person, so don't use personal pronouns such as 'I, we, our'. Also, write using the past tense. Lab report structure The title describes the purpose of the practical work in precise terms.The majority of your practical work will involve measurements, observations or the creation of some object of interest. For example: The Period of a Simple PendulumIt is clear from the above lab report title that it describes the measurement of a property called a 'period', and the object of interest is a 'simple pendulum'. The abstract provides a brief overview of the practical work, including key results and conclusions.Keep your abstract short, i.e. about one paragraph or 250 to 500 words. It must be clear enough that the reader can understand a summary of the report without needing to read the rest of it.In general, the abstract should answer six questions. Addressing each question only requires one to two sentences:Why was the experiment conducted? (big-picture/real-world view).What specific problem/research question was being addressed?What methods were used to solve the problem/answer the question? What results were obtained?What do these results mean?How do the results answer the overall question or improve our understanding of the problem?Shorter lab reports may not require an abstract, so check your guidelines first. The introduction is where you introduce the reader to the broader context of your practical work and then narrow down to the hypothesis, aims or research question you intend to address.You should also succinctly explain relevant theory and discuss any relevant laws, equations or theorems. The method section is where you describe what you actually did during the practical work. You need to describe the actions you took in a way that someone from your field has enough information to replicate the process and achieve a similar result.You must also include any unplanned changes to the original process which occurred during the execution of the experiment. A great way to keep track of this is to use a lab notebook during the practical work to note any change you make.Turn lab instructions into a lab report methodA common mistake students make is copying the instructions their teachers provide directly into their method section. You will generally be provided with a set of instructions to complete your practical work. These instructions are NOT written in the style of a laboratory report. A typical set of instructions usually includes:How the apparatus and equipment were set up (e.g. experimental set-up), usually including a diagramA list of materials used.Steps used to collect the data.Any experimental difficulties encountered and how they were resolved or worked around.Below is an example of the instructions provided to a student to carry out a first year chemistry experiment.Lab instructionsUse a clean pipette to measure 25ml of HCl(aq) into a 100ml conical flask.Rinse a burette with standardised NaOH(aq) and clamp it to the retort stand as shown Figure 2.Fill the burette to the 0.0ml marking with standardised NaOH(aq). Remember to take the reading from the centre of the meniscus, and from eye level. Record the actual reading in Table 1.Place a sheet of white paper under the burette. This is to make it easier to observe the colour change during the reaction.Place the conical flask onto the white paper and add five drop of universal indicator to the flask.Titrate the standardised NaOH(aq) into the flask with constant swirling until there is an observable colour change. (Your teacher will provide additional guidance on the specific technique).Figure 2. Experimental set-up for titration (taken from Carroll 2017) Phrases are used here to specifically instruct the student who may be performing the technique for the first time. This is different from a lab report where you are reporting on what you did. For example, the instructions say:'use a clear pipette...'.'rinse the burette...'.'remember to take the reading from the centre of the meniscus...'.'These are not appropriate phrases to include in the lab report.Also note that the language of the instructions is in the present tense in bullet points. The method section of your report should instead be written in the past tense as a cohesive paragraph.However, there are ways you can change the language of the instructions to write your method section.Below is an example of how these lab instructions were summarised into a method in a laboratory report:25ml of HCl(aq) was pipetted into a 100ml conical flask. A burette was then filled with standardised NaOH(aq). A sheet of white paper was placed under the burette. The conical flask was placed onto the white paper and five drops of universal indicator was added to the flask. The standardised NaOH(aq) was titrated into the flask with constant swirling until there was an observable colour change. While most science units require that you report in the passive voice, some require the active voice. In the example below, the first person plural is used in the active voice, i.e. "we initiated". Usage of the active voice is accepted in some disciplines, but not others. Check your unit information or talk to your teacher. InstructionYour report Initiate the bicarbonate feed pump. We initiated the bicarbonate feed pump. (active voice) The bicarbonate feed pump was initiated. (passive voice) While in science the passive voice is generally preferred, some disciplines may allow or prefer the active voice. Read samples of student reports below and identify which examples are written in passive voice, and which use active voice. The results section is where you present a summary of the data collected during your experiments. This section is not just a copy of the raw data from your lab notebook. Rather, it may involve calculation, analysis and the drawing up of tables and figures to present your data.CalculationsWhen you take your raw data and perform some sort of mathematical operation to change it, it is good practice to show the equations you used in your analysis, as well as one worked example using each equation. Calculations that are very long or repeated multiple times are usually included in an appendix (see below).In some disciplines, if formulae are used, it is common to number them as equations:Error analysisError analysis is a type of calculation that indicates the accuracy of your results, usually done by determining the level of uncertainty. The sources of error that you need to consider will vary between experiments and disciplines, but you will usually need to factor in both random and systematic errors.Any analysis and calculations of the errors or uncertainties in the experiment are included in the results section unless otherwise specified. In some disciplines the analysis and uncertainty calculations are presented under their own heading. Check the requirements given in your unit information or lab manual, or ask your tutor if you are unsure where to place calculationsTables and figuresMost numerical data are presented using tables or figures. These need to be clearly labelled following the standard conventions for captions, and titles must tell the reader precisely what data is being presented.If a measurement is stated in the title, in a column of a table or on the axis of a graph and it has units associated with it, these must be included (usually in brackets).The table below presents a series of measurements collected during an experiment. Notice the units in every column with the brackets. Some measurements such as pH or Cp do not have units.The figure below is a graphical representation of aerodynamic measurements. Notice the axes are labelled with appropriate units and the caption at the bottom of the figure clearly describes what the figure is about.Figures can also be a wide variety of images. The figure below is an image taken from a type of molecular microscope. Notice the caption at the bottom of the figure clearly describing the figure and the specification of the magnification of the microscope.If you must use figures from another source, indicate in the citation whether you have modified it in any way to avoid collusion or plagiarism. The discussion section is where you interpret and evaluate your results. To do this you need to summarise your key results, summarise unexpected results, and explain how your results relate to your aims, hypotheses or literature as stated at the start of the report. Here are some tips on writing discussion sections:Summarise key resultsIdentify and describe any trends or patterns you have observed. If these are numerical trends, state the values. Avoid using unspecific words such as 'higher, lower, increased, decreased', which can make the information vague.Compare the experimental results with any predictions you made.Interpret what the results mean in relation to the aims, research question(s) or hypothesis.Summarise key unexpected resultsDescribe any results which were unexpected or didn't match your predictions.Suggest explanations for unexpected results based on the theory and procedures of the experiment.Evaluate how any sources of error might impact on the interpretation of your results in relation to the aims, research question(s) or hypothesis.State the limitations of the study and link to literatureClarify how the limitations of the study might affect the accuracy and precision of the answers to your aim, research question or hypothesis.Suggest how the experiment or analysis could have been improved. A longer report may require support from the academic literature.Explain how your results do or do not address your aim, research question or hypothesis, and indicate future directions for the research. The discussion example below is from a first-year Biology unit. The aim of this experiment was to identify decomposition rates of leaf breakdown to establish rates of energy transfer.Drag each description of each component of the Discussion section to its example. Notice the order in which the components make up a coherent Discussion section. Students often make the mistake of thinking a conclusion section is identical to a discussion section.The conclusion section is where you summarise your report. A conclusion is usually one paragraph or 200 to 300 words. In this way a conclusion is very similar to an abstract, but with more emphasis on the results and discussion.A conclusion never introduces any new ideas or results. Rather, it provides a concise summary of those which have already been presented in the report. When writing a conclusion you should:briefly restate the purpose of the experiment (i.e. the question it was seeking to answer)Identify the main findings (i.e. the answer to the research question)note the main limitations that are relevant to the interpretation of the resultssummarise what the experiment has contributed to the broader understanding of the problem.Conclusion example with feedbackStudent's textLecturers comment The concentration of salicylic acid in commercially available aspirin tablets was determined through UV spectroscopy. Begin by describing the aims of the experiment and the method used to achieve them. The mean concentration from three different tablets was determined to be 301.1 +/-4.36 mg per tablet, which is within commercially permitted limits. Specific description of final results. Note the use of specific numbers and units. The results for individual tablets were found to be dependent on how finely the tablets were crushed before they were dissolved. Standardised approach to breaking down the tablets might further improve the accuracy of the results. Summarises the main reasons for any discrepancies and recommends improvements to overcome experimental limitations. These findings show that analytical chemistry techniques such as spectrometry can be used for fast, accurate determination of compound composition. This is important in many industries, where consistency is crucial for effective use of the product, or is vital to the safety of the product. Briefly summarise key results with respect to the broader context. When in-text citations are incorporated into your lab report (typically in the introduction or discussion) you must always have the full references included in a separate reference list. The reference list is a separate section that comes after your conclusion (and before any appendices)Check your lab manual or unit information to determine which referencing style is preferred. Carefully follow that referencing style for your in-text references and reference list. You can find examples and information about common referencing styles in the Citing and referencing Library guide.The following is an example of a reference list based on the in-text citations used in the Introduction and Conclusion sections in this tutorial. This example has been formatted in accordance with the CSIRO referencing style.Jones T, Smith K, Nguyen P, di Alberto P (2017) Effects of habitat overlap on population sampling. Environmental Ecology Journal 75, 23-29. doi: 10.5432/1111.23Tian M, Castillo TL (2016) Solar heating uptake in Australia: rates, causes and effects. Energy Efficiency Reports. Report no. 10, The Department of Sustainability and Environment, Canberra. An appendix (plural = appendices) contains material that is too detailed to include in the main report, such as tables of raw data or detailed calculations.Each appendix must be:given a number (or letter) and titledreferred to by number (or letter) at the relevant point in the text.ExampleThe calculated values are shown in Table 3 below. For detailed calculations, see Appendix 1.



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