

I am in the middle of revising this hyperbook. The revised part has the light yellow background of most of this page. Parts that have yet to be revised appear on a pink background like the one used for this paragraph. The pink parts are inconsistent with the revised part of the document; they may duplicate earlier material and may depend on earlier material that I removed. They may also include sections that I was still writing when I stopped and began the revision.

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About This Hyperbook

This is a hypertext book, or *hyperbook*, that is in the process of being written. The hyperbook has two tracks: The *Principles* track is about the principles of concurrent programming; the *Specification* track is about specification—mainly of concurrent systems. The two tracks run together for the first 6 sections; the reader of just one of the tracks can jump past sections that pertain only to the other track. The two tracks then separate.

The two tracks use TLA^+ as the underlying language for describing algorithms and systems. Both include a tutorial on TLA^+ and its tools. Most of the algorithms in the *Principles* track are not written directly in TLA^+ . Instead, they are written in PlusCal, an algorithm language that is automatically translated to TLA^+ .

The *Principles* track contains informal proofs and proof sketches. There is an optional *TLA^+ Proof* track for readers who want learn to write formal proofs and check them with the [TLA⁺ Proof System](#). I recommend that anyone who writes even informal proofs read at least part of the *Proof* track.

All the tracks assume that you are using the [TLA⁺ Toolbox](#). Readers should also check out the [TLA Home Page](#), which will point you to other resources including the TLA^+ Google Group.

The hyperbook is a work in progress. Sections that are not yet completed are marked with section headings [colored like this](#). Even sections that have been completed are likely to be rewritten. However, there is enough to help you get started learning about TLA^+ . As I write the hyperbook, I will continually update the version posted on the Web. Check [the hyperbook's web site](#) regularly to see if there is a newer version than this one.

You can help make the hyperbook better by telling me your reaction to both its form and its content. Let me know what you like, what you don't like, and what you want to see but don't. Please don't suggest wonderful hyper-text features unless you know how to implement them in pdf—preferably using PDF_{TEX}. (Don't shoot the author; he's doing the best he can.)

The hyperbook consists of a collection of pdf files that are designed to be read on-line with a pdf viewer. I generally use the [Adobe Reader](#), but other

viewers such as the [Foxit Reader](#) should also work. As I write, I am using the latest Windows version of Adobe Reader, which is version 11.0.5. I can't promise that it will work with other versions or with other operating systems or with a pink mouse. Please let me know if it doesn't.

I recommend that you read the rest of this section before reading any of the hyperbook. But if you get impatient, you can get right to it by clicking the **C** button in the left margin. You can come back to this section at any time by clicking on the **?** button in the left margin.

Links

A piece of text that is [this color](#) is a link. It is usually either a [link to a pop-up](#), or a [link to ordinary text](#), which you should click now. For a link that looks like [this](#)[□], clicking on the text opens the linked text in the same window; clicking on the □ opens the linked text in a new window. If you haven't already clicked on the □, do it now.

A link can also be to a Web page—for example, [here's a link to the Adobe Reader page](#). Such a link might not work unless your browser is already running.

If you have difficulty distinguishing colors and cannot tell a link from ordinary text, please [click here to contact me](#) and I will try to produce a version of the hyperbook for you and others with the same problem.

TLA⁺ Source Text

This hyperbook teaches you how to use the [TLA⁺ Toolbox](#) to check your specifications and algorithms. To save you typing, it contains a lot of example PlusCal and TLA⁺ “code” that you will want to copy and paste. To make this possible, the ASCII versions that you need to use are provided. For small examples, the printed version and the ASCII version appear side by side, as in this example:

TRUE \wedge FALSE

TRUE \wedge FALSE

To copy the ASCII text, select it with the mouse (left-click and drag) and **type control+c**. You can then click the spot where you want the text to go and **type control+v** to paste it there. For longer examples, the ASCII version is provided in a pop-up, as in this example.

$$\begin{aligned} A &\triangleq \wedge x > y \\ &\wedge \langle x, y \rangle \in S \\ &\wedge x' = x + y \end{aligned}$$


[ASCII version](#)

Click on the link in the margin to get the ASCII version. To copy the contents of the window, **type control+a control+c**. Often, as in this case, spaces are shown

as □ to ensure that they are copied correctly. For larger examples, both the printed version and the ASCII version may be provided in pop-ups.


For a few of the ASCII version popups, selecting the text in Adobe Reader fails to capture many of the spaces, destroying the formatting when you paste the text into a specification. (When you select the text, you will see that those spaces are not highlighted.) I have been unable to determine what it is about these popups that causes Adobe Reader to behave in this way. Perhaps there still lurks in Adobe someone who could explain this behavior. The Foxit Reader does not appear to have this problem.


[Click here](#)□ for a list of all special symbols and how they are typed in ASCII.


If you got here by clicking on a link, you can go back to where you came from by clicking on the  button in the left margin.


The Left-Hand Column


The buttons on the left-hand side of the page perform the following actions:


 Go to this page.

 *Back* navigation button. (On some operating systems, Adobe Reader seems able to go back only to a location within the same file.)

 *Forward* navigation button.

 Go to the table of contents.

 Go to the index. Eventually, every symbol or term whose meaning you might have forgotten will be indexed, with links to its explanation and other significant uses.

 Go to a very short summary of the TLA⁺ language, which includes the list of [ASCII versions of symbols](#)□.

Size

Adjusting the size of the reader's window adjusts the size of the print. The best way to do this is first to make the window very wide. This will show a black area on both sides of the page. Then, adjust the height of the window so the page is the size you want it. Finally, narrow the window until the black area on the sides disappears.

The hyperbook is designed to be read as a continuous scroll, rather than as a sequence of separate pages. As of Version 11.0.3 on 15 May 2013 at 9:33 UT, you can set Adobe Reader to display the hyperbook as a continuous scroll by going to the **Edit / Preferences / Accessibility** menu and selecting **Always use Page Layout Style / Single Page Continuous**. When you scroll, you might see a

black space between pages. In Adobe Reader, you can unselect the **View / Page Display / Show Gaps Between Pages** menu option to change the black space to a dashed line. At the moment, it appears that you have to do this only once and the setting applies to all documents. This might change if Adobe learns that it is too convenient.

The Toolbox Help Pages

The hyperbook contains links to some of the Toolbox's help pages, which are on the Web at <http://tla.msr-inria.inria.fr/tlatoolbox/doc/contents.html>. How to find the copies of the Web pages in the Toolbox itself is explained on [this help page](#).

You can begin both Tracks by clicking [here](#).

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