mxGraph User Manual – JavaScript Client

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mxGraph – An Introduction

Table of Contents

1 Introduction

Move to the following sections:

- 1.3 if you just want to know what this version of mxGraph actually does,
- 1.5 if you're wondering what the high-level view of deploying this technology looks like,
- 1.7 if you need to understand the licensing options better,
- 1.9 if you'd like to know how you can get your technical and commercial mxGraph questions answered,
- 2.1.2 if you just want to see an example up and running.

1.1 MxGraph Product Family Introduction

mxGraph is a product family of libraries, written in a variety of technologies, that provide features aimed at applications that display interactive diagrams and graphs. Note by graphs we mean mathematical graphs, not necessarily charts (although some charts are graphs). See later section "What is a Graph?" for more details.

Being a developer library, mxGraph is not designed specifically to provide a ready to use application, although many of the examples are close to being usable applications. mxGraph provides all the commonly required functionality to draw, interact with and associate a context with a diagram displayed in the technology of that particular mxGraph flavour. mxGraph comes with a number of examples that help explain how a basic application is put together using each technology and showcases individual features of the library.

Each user manual is specific to one technology, along with generic sections, such as this introduction and layouts. Developers will find the implementations of each library in the different technologies share the same architecture and API across the product range. The implementations differ slightly for technology-specific areas, usually event handling and rendering, but when overall porting from one technology, mxGraph is designed to present as common an interface as is possible.

mxGraph, at the time of writing, has a commercial release grade JavaScript library, a beta stage Java Swing visualization library and alpha grade ActionScript (for Flex applications) and .NET visualization components. Do not confuse the visualization elements (the part you see on the client) with the core model elements. The core models written in Java, .NET and PHP that serve as back-end server classes in the JavaScript library versions are all commercial-grade production code.

Developers integrating the library in their application should read the pre-requisites for the technology they are using. See section "Pre-requisites" below. Given that mxGraph is a component part of your application, you must understand how applications are constructed in that technology and how to program in the language(s) of that technology.

1.2 Which version of mxGraph to use?

When deciding which of the technology implementations of mxGraph to use, often the choice is determined by the technology of the application.

The .NET and Java visualization versions are suitable for producing desktop applications with high performance. The .NET technology is aimed at Windows applications and Java at a number of operating system platforms. Selection of one of those technologies is usually because of background knowledge of the developers using the library.

The two web-centric technologies, JavaScript and ActionScript have specific advantages and disadvantages relative to one another. You would select one of these two technologies when you are intending to provide interactive diagramming in standard web browsers with some centralised servers providing persistence and coordinating delivery of the visualization data between clients.

An example of such an application is a business process modelling tool that enables users to draw processes in a web browser, store them centrally, allow other users to view and edit processes and automatically execute the process on the server using business logic associated with the visual information.

1.2.1 JAVASCRIPT

The JavaScript version of mxGraph mainly comprises one JavaScript file that contains all of the mxGraph functionality. This is loaded into a HTML web page in a JavaScript section and executes in an HTML container in the browser. This is an incredibly simple architecture that only requires a web server capable of serving html pages and a JavaScript enabled web browser.

The key advantages of this technology are:

- That no third-party plug-ins are required. This removes plug-in vendor dependence.
- The technologies involved are open and there are many open implementations, no vendor can remove a product or technology that leaves your application unworkable in practise.
- Standardized technologies, meaning your application is deployable to the maximum number of browser users without need for additional configuration or installation at the client computer. Large corporate environments often dislike allowing individuals to install browser plug-ins and do not like to change the standard build rolled out to all machines.

The key disadvantage of this technology is:

- Rendering speed. As the number of cells visible on the users screen climbs into the hundreds, redrawing slows on most browsers beyond acceptable levels. In information management theory displaying several hundred cells is generally incorrect, since the user cannot interpret the data. There are a number of mechanisms, collectively known as complexity management used to limit the amount of information to sensible levels, and thus maintaining reactive redraw rates for the user. Complexity management is described in a later section of this user manual.

1.2.2 FLEX/FLASH

- The ActionScript version of mxGraph is designed to be integrated into a Flex application. Flex is a web application framework written by Adobe that uses the Flash browser plug-in. The key advantages of using this technology are:

The graphics performance is very good, there are not the rendering speed issues of the JavaScript library with large graphs

Flex provides an application framework providing a clear process for the developer to produce the application, with IDE tools available to speed up development.

Adobe also produce a toolkit named AIR, that enables Flex to be deployed as a native application. this enables a desktop and browser based version to be written using the same basic technology.

The key disadvantages of ActionScript as a technology are:

The technology is proprietary, the standards and tools are not all open (note the Flex SDK is open source, however) and thus this creates a vendor dependence for your application.

A plug-in is required on each browser, which assuming the application is written in ActionScript version 3, would need to be at least Flash version 9. The penetration figures for Flash are very high, though you are recommended to investigate whether or not they are quite as high as indicated on the Adobe web site for your specific user base.

Comparing the pros and cons of each implementation against your application requirements usually provides a clearly advantage to using one of these technologies.

1.3 mxGraph – JavaScript Library

This user manual is for the JavaScript library version of mxGraph, that enables you to produce web applications that feature interactive diagramming functionality across all major browsers, without the use of third-party plug-ins. The core client functionality of mxGraph is a Javascript library that describes, displays and interacts with your diagram through a browser, providing all the commonly required application features as well as easy extensibility to add custom features. mxGraph is designed for use in a client-server architecture, where the Javascript library communicates with a server and exchanges information on the state of the graph.

Note: From now on the term **mxGraph** will be used to describe the JavaScript client and supporting back-end modules, rather than any other flavour of the product, unless otherwise specified.

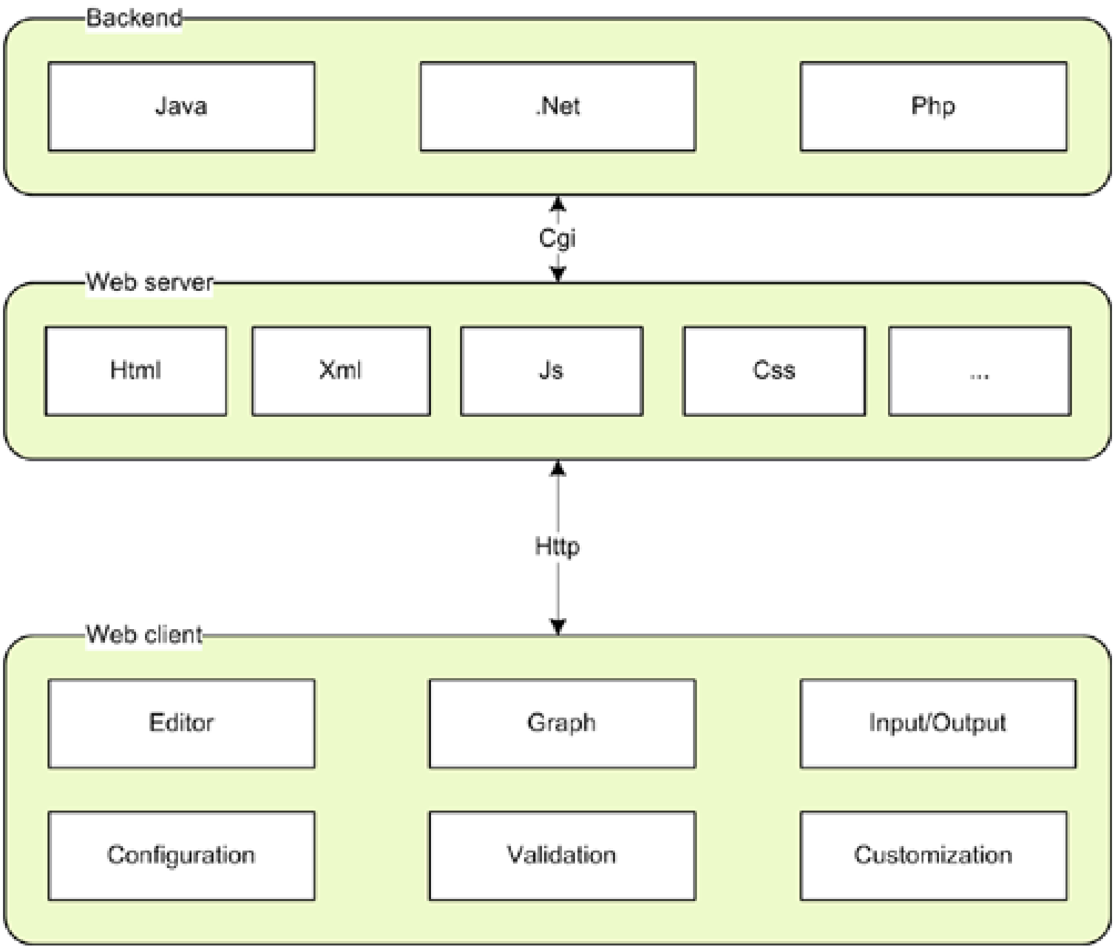


Illustration 1: The mxGraph components and their relationships

1.4 What Applications can mxGraph be used for?

Example applications for a graph visualization library include: process diagrams, workflow and BPM visualization, flowcharts, traffic or water flow, database and WWW visualization, networks and telecommunications displays, mapping applications and GIS, UML diagrams, electronic circuits, VLSI, CAD, financial and social networks, data mining, biochemistry, ecological cycles, entity and cause-effect relationships and organisational charts.

1.5 How is mxGraph deployed?

In the typical thin-client environment, mxGraph is split into the client-side JavaScript library and a server-side library in one of the three supported languages, .NET, Java and PHP. The JavaScript library is contained as part of a larger web application that is delivered to the browser using a standard web server. All the browser needs is the ability to run JavaScript to be enabled.

In section 3, you will see an example of an html page that embeds the mxGraph library, as well as a simple application to invoke the library's functionality.

1.6 mxGraph Technologies

mxGraph uses JavaScript for the client-side functionality on the browser. The JavaScript code in turn uses the underlying vector graphics language on the active browser to render the displayed diagram, SVG for the more standards compliant browsers and VML in the case of Microsoft Internet Explorer. mxGraph also includes the feature to render entirely using html, this limits the range of functionality available, but is suitable for more simple diagrams.

As a developer you are not exposed to browser specific features. As mentioned, the vector graphics language varies by browser, so mxGraph abstracts their features into a common class. Similarly, for event handling and DOMs. Browsers differ in their implementation of these two major browser functionalities, mxGraph exposes a constant API over all browsers and adapts to the inconsistencies behind the scenes.

1.7 mxGraph Licensing

The JavaScript client of mxGraph may be licensed in two ways:

- Under a standard commercial license, the pricing on the web site applies to these commercial licenses.
- Under a non-commercial, non-profit license, given some proof of these states. Non-commercial means not for use within a commercial company. Use the contact form on the web site for details.

Note that both licenses forbid you as a developer to redistribute source code to mxGraph, other than the compressed mxClient.js file with your application. This means that the mxGraph licenses are not compatible with open source or free software licenses. You may also not make the sources publicly visible on the Internet.

For detailed licensing questions you are always advised to consult a legal professional.

1.8 What is a Graph?

Graph visualization is based on the mathematical theory of networks, graph theory. If you're seeking JavaScript bar *charts*, pie *charts*, Gantt *charts*, have a look at the Google Charts project instead, or similar

A graph consists of vertices, also called nodes, and of edges (the connecting lines between the nodes). Exactly how a graph appears visually is not defined in graph theory. The term *cell* will be used throughout this manual to describe an element of a graph, either edges, vertices or groups.

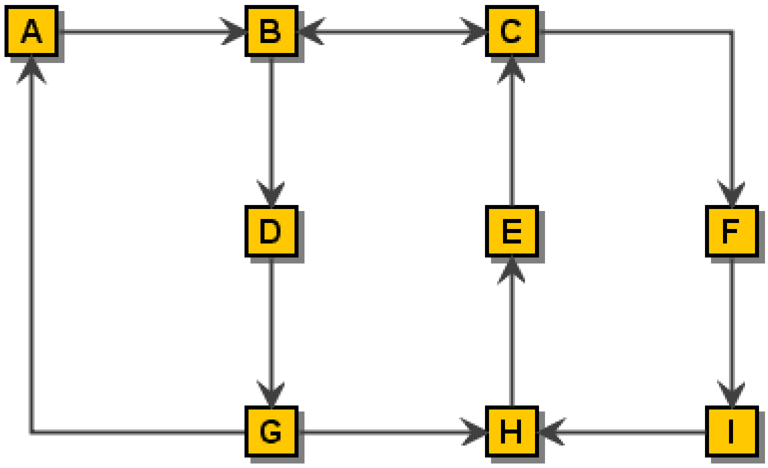


Illustration 2 : A simple Graph

There are additional definitions in graph theory that provide useful background when dealing with graphs, they are listed in Appendix A if of interest to you.

1.8.1 GRAPH VISUALIZATION

Visualization is the process of creating a useful visual representation of a graph. The scope of visualization functionality is one of mxGraphs' main strength. mxGraph supports a wide range of features to enable the display of cells to only be limited by the skill of the developer and the platform functionality available. Vertices may be shapes, images, vector drawing, animations, virtually any graphical operations available in browsers. You can also use HTML mark-up in both vertices and edges.

Illustration 3 : Graph Visualization of a transport system. (c) Tourizm Maps 2003, http://www.world-maps.co.uk

1.8.2 GRAPH INTERACTION

Interaction is the way in which an application using mxGraph can alter the graph model through the web application GUI. mxGraph supports dragging and cloning cells, re-sizing and re-shaping, connecting and disconnecting, drag and dropping from external sources, editing cell labels in-place and more. One of the key benefits of mxGraph is the flexibility of how interaction can be programmed.

Many complex graphical web applications rely on a round-trip to the server in order to form the display, not only the base display but also the interaction events. Although this is often given the title of AJAX functionality, such server reliance is not appropriate for interaction events. Visual feedback taking longer than about 0.2 seconds in an application generally seriously impacts the usability. By placing all of the interaction on the client, mxGraph provides the true feel of a application, rather than seeming like a dumb remote terminal. It also allows the possibility of off-line use.

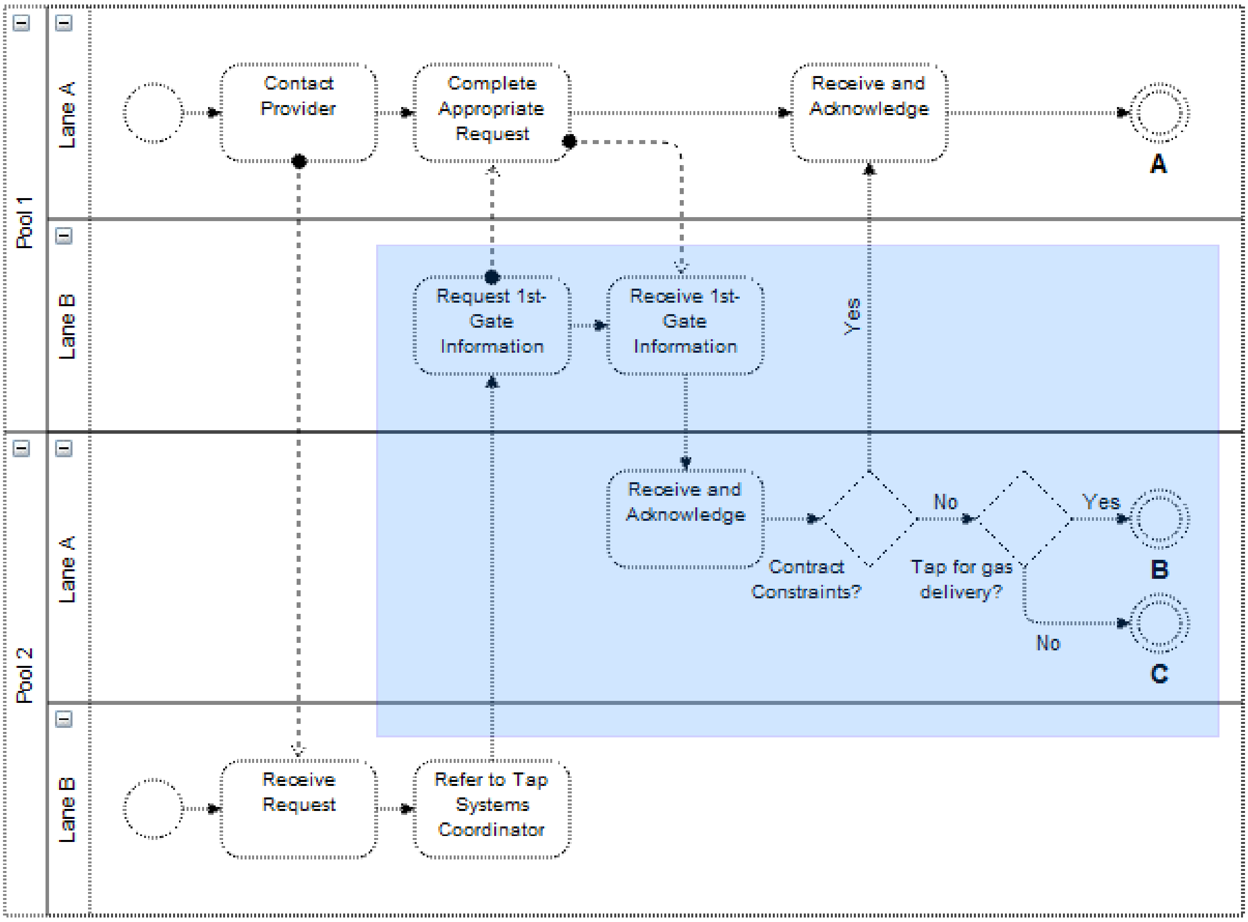


Illustration 4: Selection shading while selecting an area through mouse drag

1.8.3 GRAPH LAYOUTS

Graph cells can be drawn anywhere in a simple application, including on top of one another.

Certain applications need to present their information in a generally ordered, or specifically ordered structure. This might involve ensuring cells do not overlap and stay at least a certain distance from one another, or that cells appear in specific positions relative to other cells, usually the cells they are connected to by edges. This activity, called the layout application, can be used in a number of ways to assist users in setting out their graph. For non-editable graphs, layout application is the process of applying a layout algorithm to the cells. For interactive graphs, meaning those that can be edited through the UI, layout application might involve only allowing users to make changes to certain cells in certain positions, to re-apply the layout algorithm after each change to the graph, or to apply the layout when editing is complete.

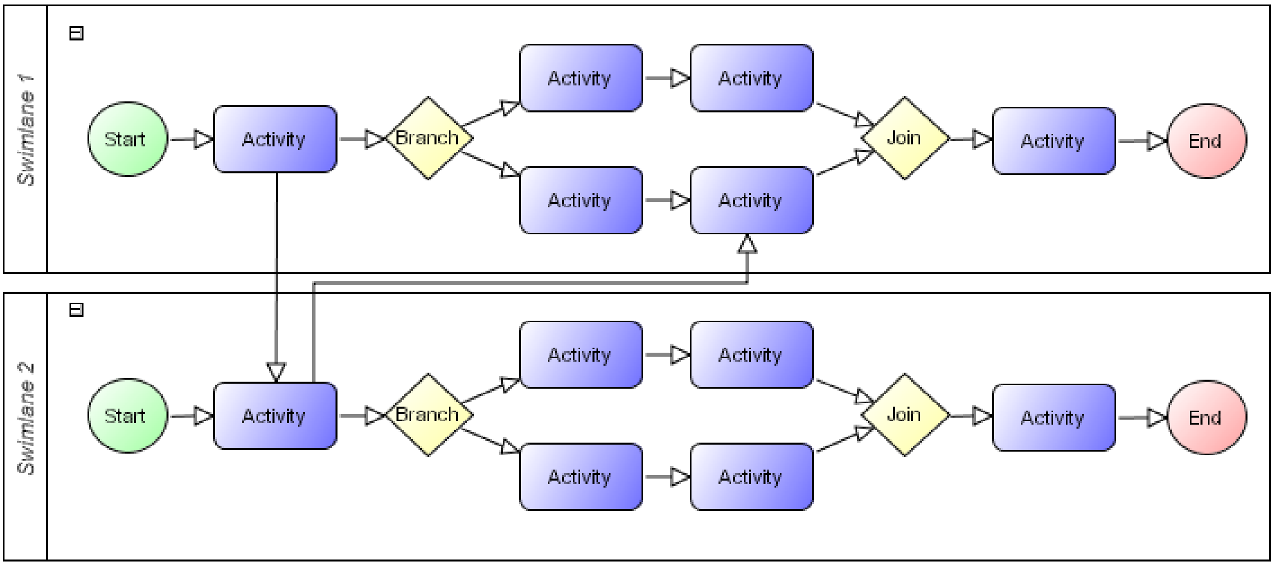


Illustration 5 : Layout of a workflow using a horizontal hierarchical layout

mxGraph supports a range of tree, force-directed and hierarchical layouts which will fit most layout needs. See the later section on using the layouts for more information.

In a client-server architecture there are two options for how layouts can be run. The Javascript versions provide the ability to run the layouting entirely on the client, while the same layout implementation in Java on the server-side enables the option to offload some processing to the server, if required.

1.8.4 GRAPH ANALYSIS

Analysis of graphs involves the application of algorithms determining certain details about the graph structure, for example, determining all routes or the shortest path between two cells. There are more complex graph analysis algorithms, these being often applied in domain specific tasks. Techniques such as clustering, decomposition, and optimization tend to be targeted at certain fields of science and have not been implemented in the core mxGraph packages at the current time of writing.

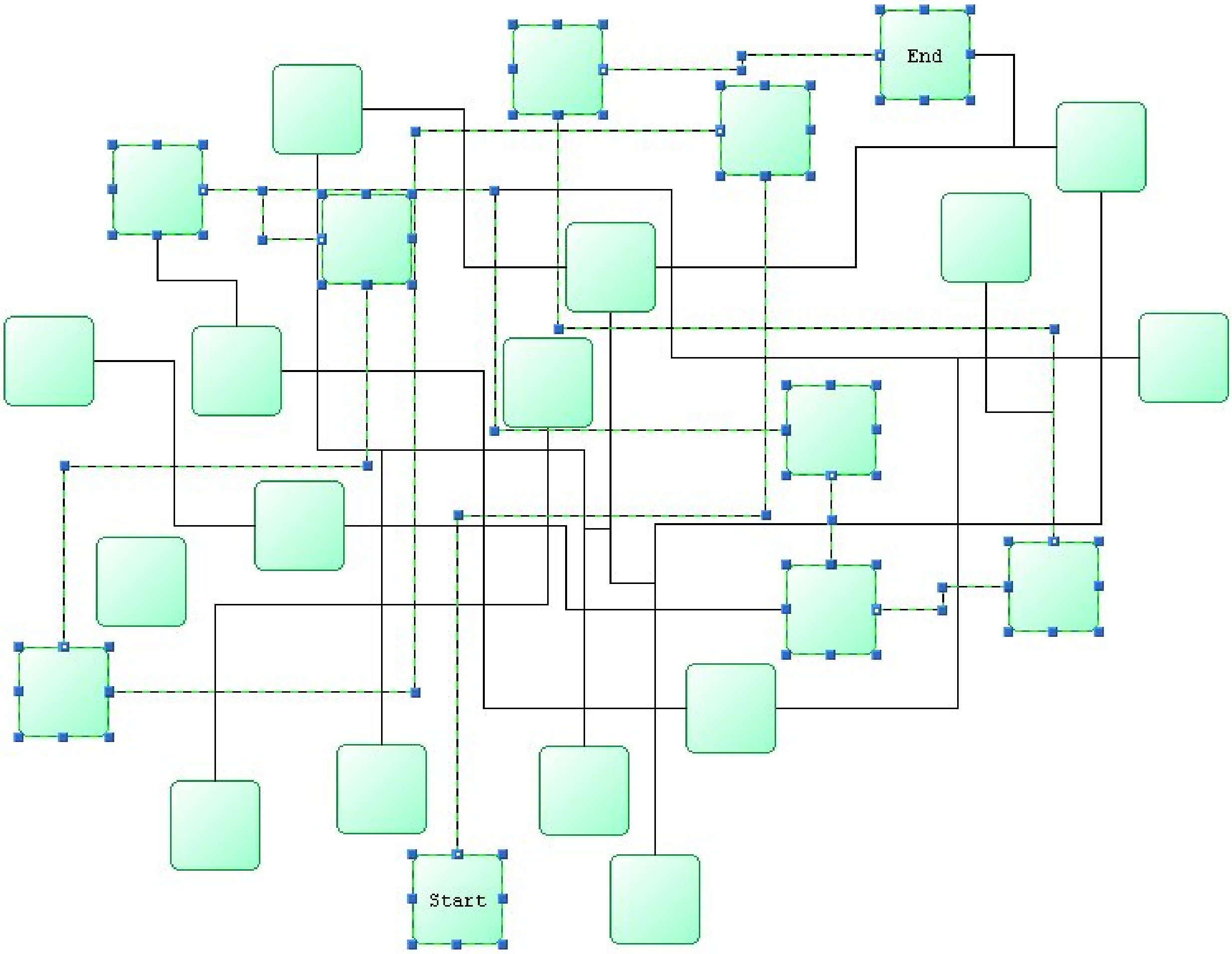


Illustration 6 : Shortest Path Analysis

1.9 About this Manual

1.9.1 PRE-REQUISITES FOR MXGRAPH

To benefit fully from this manual you will need to have a reasonable understanding of web applications and of the server technology you wish to deploy using. Deployment examples are available for each of the server technologies supported, some familiarity with that server technology is obviously required.

Basic XML knowledge is useful for changing the editor configuration files that describe the visual and behavioural aspects of the editor. You will need to understand and implement Javascript coding and be familiar with object orientated programming principles and modern software design.

You do not need knowledge of the underlying vector graphics language that the browser uses, such as SVG, VML or XAML. mxGraph abstracts the description of the visual component into one API.

1.9.2 GETTING ADDITIONAL HELP

There are many mechanisms for receiving help for working with the mxGraph software. The community help forum provides free assistance to mxGraph users. The forums combine the advantages of many users helping to answer questions along with the guidance of active mxGraph developers ensuring the quality and correctness of responses and that as many questions as possible are answered. However, there is no assurance of getting free assistance, either the answer being correct, or getting an answer at all. If your question is non-trivial there is less chance of a developer finding free time to analyse your problem, please try to break the problem down into simple issues and provide as much information and examples as you can.

When posting at the forums these posting guidelines will help you get a better answer and encourage more people to help you. Please note that the mxGraph team cannot guarantee that answers provided on the forums are correct as they cannot always monitor all discussion threads. If you require guaranteed response time support and require the answer to your technical questions to be correct please contact JGraph Sales for support contract information. The full version of mxGraph comes with 12 months technical support by default.

2 Getting Started

2.1.1 THE MXGRAPH WEB SITE

To start, navigate to the mxGraph web site. The most useful areas to you when starting mxGraph are listed below. Use the navigation bars on the top and bottom to locate the appropriate section:

- Download – Here you can download the latest evaluation copy. See section below on evaluation for more details.
- Forum - Here you can ask the JGraph community your questions. A timely and correct answer cannot be guaranteed, however the JGraph developers tend to keep a close eye on questions posted. Try to break your problem down into single smaller questions. If you post asking to have someone write your project for you, you are unlikely to receive a reply. If you require commercial-level support please contact support@jgraph.com. Before posting to the forum please search the documentation, the FAQs and search the forum using the search facility provided. The JGraph team have spent a great deal of effort putting those resources in place, please try to save them having to point you at them because you have not searched yourself.
- Tracker - The tracker contains current bugs within mxGraph, ensure you specify the mxGraph project when searching the database. If you think you have a bug, check it has not already been reported and also check in the forum if you are unsure if it is a real bug. If you are sure, please do report the bug.

2.1.2 OBTAINING MXGRAPH

There are two methods to obtain mxGraph. Commercial customers receive distributions through a protected download site described in their purchase email. Non-commercial customers can request a copy of the software via the contact page on the web site. Non-commercial means not for use within a commercial organisation, it does not mean you do not intend to sell the derived application.

To evaluate mxGraph commercially:

- Navigate to the evaluation download page.
- Select the check box to indicate agreement to the license and click the button "Download Now" to download.
- The downloaded package is zipped, unzip to your preferred location.
- Within the package under javascript/examples you will find a number of html files that demonstrate how to invoke the library within a web page.
- To create your own example, copy the basic structure of the examples and add your extensions/changes to the onload invoked JavaScript main function.
- The evaluation copy is valid for 90 days after download. If you wish to continue evaluation, purchase mxGraph or request an academic license, please use the contact form.
- For commercial evaluations looking for commercial grade evaluation support, again, please use the contact form.

The only functional difference between the evaluation and full version of mxGraph is the layout functional is not available in the evaluation version. If you are a commercial company evaluating and wish to evaluate layouts, again, please use the contact page on the web site.

2.1.3 INSTALLING MXGRAPH

Both the evaluation and full versions of mxGraph are delivered as zip files. Unzip the package to your preferred location, a folder named mxGraph will be created there, this folder is the root folder of the mxGraph installation.

2.1.4 PROJECT STRUCTURE AND BUILD OPTIONS

Once unzipped you will be presented with a number of files and directories in the installation root.

/doc	Documentation root, includes this user manual
/dotnet	.NET server-side classes
/java	Java server-side classes
/javascript	JavaScript client functionality.
/javascript/examples	HTML examples demonstrating the use of mxGraph
/php	PHP server-side classes
ChangeLog	Details of the changes between releases
readme.html	Basic introduction to the library
license.txt	The licensing terms under which you must use the library

Table 1. Project Directory Structure

Move to section 2.3 if you are familiar with JavaScript development and want to start developing with mxGraph.

2.2 JavaScript and Web Applications

Web applications, specifically the use of JavaScript to attempt to emulate desktop application-like behaviour in web browsers, is still a relatively new field of software engineering. There are three main issues with JavaScript that are perceived to be a barrier to producing high quality applications, performance, lack of native functionality available in desktop applications and inconsistent APIs between browsers.

There has been considerable effort toward developing framework libraries to solve two of the problems, the functionality and API issues. The requirements of many of these libraries is driven by both improving web site design and usability, as well as to assist production of what we generally refer to as application features (menus, windows, dialogs, persistence, event handling, etc). They also provide certain base functionalities missing in JavaScript that desktop application developers take for granted, such as basic maths and collections functionality.

Many of these JavaScript frameworks have IDE support for development nowadays and all of the major browsers now contain JavaScript debuggers, either natively or as a plug-in. There is no compilation phase with JavaScript (it is an interpreted language) so basic typographical errors are often only caught at runtime, unless you obtain a syntax checking tool in your IDE. So although there is not one complete package for your JavaScript development needs, there are a number of vendors providing the individual components you need to produce JavaScript applications effectively.

2.2.1 AJAX

AJAX is a very fashionable term applied freely to make JavaScript applications sound more modern. The idea of AJAX was originally to enable communication with a server without leaving the client browser hanging in a loop waiting for the response. Strictly speaking, the basic functioning of mxGraph involves no AJAX. All of the interaction and model changes are applied on the client in JavaScript.

Alternative approaches to display interaction diagrams have been taken that use the AJAX approach, but weary of the AJAX term to suggest that the solution is technological more advanced. Going back to the server for interaction changes, in particular, cause serious delays in updating the UI, often making the application unusable.

2.2.2 THIRD-PARTY JAVASCRIPT FRAMEWORKS

2.2.2.1 Google Web Toolkit

Given the apparent complexity from a desktop developer's point of view, a common approach is to use the Google Web Toolkit (GWT). GWT provides many commonly required web application features by translating Java into JavaScript. This JavaScript can be deployed just as natively written JavaScript is. GWT also provides the option to obfuscate the resulting JavaScript. (See later section on obfuscation in this chapter).

The key advantages of GWT are:

- Reuses Java developer knowledge,
- Allows debugger of the Java source,
- Resolves cross-browser issues,
- Native code can be interleaved with Java,
- Certain compile-time errors can be detected before execution.

The key disadvantages of GWT are:

- Commercial support is not available from the developers,
- The higher the level of abstraction, the more difficult it is to implement features that go against the architecture and to debug when things go wrong,
- It's use may deter from learning and understanding JavaScript, which is ultimately necessary to implement certain new features.

In summary, consider GWT for simpler projects, but be wary of placing to much emphasis on it as a tool that avoids having to learn JavaScript properly.

2.2.2.2 Native JavaScript Frameworks and Libraries

Rather than list and compare every JavaScript framework, please see the wikipedia entries for web application frameworks and the comparison of JavaScript. The comparison should not be considered authoritative, more so it illustrates the types of features provided, such as event handling, animation, widgets, AJAX request support etc. This site is also a useful list of JavaScript libraries, mostly being open/free source licensed.

One important issue missed off from the comparison list is where commercial support is available. ExtJS control their framework in-house and offer a number of support packages to assist developers using it. The mxGraph developers used ExtJS for the GraphEditor example and found it to be an easy way to give a web application a desktop application look.

Sitepen offer support services for two of major frameworks, DOJO and the Yahoo User Interface Library (YUI). Both these libraries offer the advantage of a small core that can be optionally extended. However, those support services do not necessarily have direct control of the code base of the two projects, particularly in the case of YUI, so altering the code base to customer requests might not be possible. However, DOJO and YUI are both large, well established projects with large commercial backing of their development. Both make the, very sensible, decision to have a very small core that provides basic features such as browser detection and event unification and leave additional functionality to extensions.

Be aware that many frameworks add implicit behaviours to make JavaScript appear more like an OO language and to increase the base functionality of the language. During the writing of the layout portion of mxGraph, it was found that this implicit behaviour broke an example in a very hard to debug manner. Be aware that this may cause problems and if you select a framework ensure you understand which implicit behaviours it introduces.

When selecting a framework and/or libraries think about which frameworks tie you into certain functional behaviour and look for libraries that provide features such as animation as distinct, independent blocks, that you can use without being tied into the overall design.

2.2.2.3 Integration of mxGraph and JavaScript frameworks

This area is often misunderstood, put simply, there is no *integration* required. Web applications generally comprise one or more *div* elements into which the HTML wrapping the JavaScript of the application is placed. If you create a div as a container for an mxGraph, that area is a stand-alone display for the mxGraph application. It can communicate itself with any back-end server, but there is no interdependence between that div and the rest of the page, other than the area each take up. This includes event handling, mxGraph can handle the events for its container, even if the rest of the web page used a completely different event model. As long as neither mxGraph nor the other libraries and frameworks on the page do introduce implicit behaviours that break one part of the page, the issue of client integration is not something that needs analysis.

Integration of the mxGraph back-end functionality, that which sits at the server-side is the subject of a later chapter.

2.2.2.4 Extending mxGraph in JavaScript

In JavaScript, there are various ways of mapping the Object Oriented paradigm to language constructs. mxGraph uses a particular scheme throughout the project, with the following implicit rules:

- Do not change the built-in prototypes
- Do not try to limit the power of the JavaScript language.

There are two types of "classes" in mxGraph; classes and singletons (where only one instance of the class exists). Singletons are mapped to global objects where the variable name is the same as the class name. For example, mxConstants is an object with all the constants defined as object fields. Normal classes are mapped to a constructor function and a prototype which defines the instance fields and methods. For example, mxEditor is a function and mxEditor.prototype is the prototype for the object that the mxEditor function creates. The *mx* prefix is a convention that is used for all classes in the mxGraph package to avoid conflicts with other objects in the global namespace.

For subclassing, the superclass must provide a constructor that is either parameterless or handles an invocation with no arguments. Furthermore, the special constructor field must be redefined after extending the prototype. For example, the superclass of mxEditor is mxEventSource. This is represented in JavaScript by first "inheriting" all fields and methods from the superclass by assigning the prototype to an instance of the superclass, e.g.

```
mxEditor.prototype = new mxEventSource()
```

and redefining the constructor field using:

```
mxEditor.prototype.constructor = mxEditor
```

The latter rule is applied so that the type of an object can be retrieved via the name of it's constructor using `mxUtils.getFunctionName(obj.constructor)`.

2.2.2.4.1 Constructor

For subclassing in mxGraph, the same mechanism should be applied. For example, for subclassing the mxGraph class, first a constructor must be defined for the new class. The constructor calls the super constructor with any arguments that it may have using the *call* function on the mxGraph function object, passing along explicitly each argument:

```
function MyGraph(container)
{
     mxGraph.call(this, container);
}
```

The prototype of MyGraph inherits from mxGraph as follows. As usual, the constructor is redefined after extending the superclass:

```
MyGraph.prototype = new mxGraph();
MyGraph.prototype.constructor = MyGraph;
```

You may want to define the codec associated for the class after the above code (see I/O section of manual). This code will be executed at class loading time and makes sure the same codec is used to encode instances of mxGraph and MyGraph.

```
var codec = mxCodecRegistry.getCodec(mxGraph);
codec.template = new MyGraph();
mxCodecRegistry.register(codec);
```

2.2.2.4.2 Functions

In the prototype for MyGraph, functions of mxGraph can be extended as follows.

```
MyGraph.prototype.isSelectable = function(cell)
{
     var selectable = mxGraph.prototype.isSelectable.apply(this,
arguments);
```

```
	var geo = this.model.getGeometry(cell);
	return selectable && (geo == null || !geo.relative);
}
```

The supercall in the first line is optional. It is done using the *apply* function on the *isSelectable* function object of the mxGraph prototype, using the special *this* and *arguments* variables as parameters. Calls to the superclass function are only possible if the function is not replaced in the superclass as follows, which is another way of "subclassing" in JavaScript.

```
mxGraph.prototype.isSelectable = function(cell)
{
	var geo = this.model.getGeometry(cell);
	return selectable &&
		(geo == null || !geo.relative);
}
```

The above scheme is useful if a function definition needs to be replaced completely.

In order to add new functions and fields to the subclass, the following code is used. The example below adds a new function to return the XML representation of the graph model:

```
MyGraph.prototype.getXml = function()
{
	var enc = new mxCodec();
	return enc.encode(this.getModel());
}
```

2.2.2.4.3 Fields

Likewise, a new field is declared and defined as follows:

```
MyGraph.prototype.myField = 'Hello, World!';
```

Note that the value assigned to myField is created only once, that is, all instances of MyGraph share the same value. If you require instance-specific values, then the field must be defined in the constructor instead. For example:

```
function MyGraph(container)
{
	mxGraph.call(this, container);
	this.myField = new Array();
}
```

Finally, a new instance of MyGraph is created using the following code, where container is a DOM node that acts as a container for the graph view:

```
var graph = new MyGraph(container);
```

2.2.3 GENERAL JAVASCRIPT DEVELOPMENT

2.2.3.1 JavaScript Development Environments

Please refer to the ExtJS manual entry on the subject.

2.2.3.2 Debugging JavaScript

Please refer to the wikipedia entry, or to the ExtJS manual entry, for information on the subject.

2.2.3.3 JavaScript Obfuscation

By default, when you deliver JavaScript to a browser client, you deliver the entire source to that JavaScript. That JavaScript is then interpreted and run on the browser. It is not possible to encrypt the JavaScript to any extent on the client at the point it is run, since the JavaScript source must be understood by the JavaScript interpretor and interpreted languages do not have a binary intermediate form.

It would be possible to encrypt the JavaScript in transmission and have it decrypted and run on the client, but the client would still be able to access the source after decryption.

We do not obfuscate because the method names form a public API and I/O would need to understand the obfuscation at both communication ends.

2.2.3.4 Namespaces

The concept of namespaces does not exist in JavaScript, so take great care when creating new class names. In mxGraph, all of the classes begin with the prefix "mx-", to avoid clashes or overriding prototypes unintentionally. Prior to starting your application it is worth creating a prefix particular to your application that you append to all of the your classes to create a manual "namespace".

2.3 Hello World!

Hello World in mxGraph consists of a simple client-side example that displays two connected vertices with the labels "Hello" and "World!". The example demonstrates the following things:

- Creating an HTML page that links the mxGraph client JavaScript,
- Creating a container to place the mxGraph into,
- Adds the required cells to that graph.

The source code for the example, helloworld.html, can be found below and in the examples directory of both the evaluation and full versions of mxGraph. The HTML source contains two main sections, the head and the body. These contain the following main elements that you can consider a template for building a basic mxGraph application:

- **mxBasePath** : This is a JavaScript variable that defines the directory within which the css/, images/ and js/ directories are expected to be found. It is JavaScript code and needs to be placed with in a *script* tag. This must come before the line loading the mxClient.js file.

- **mxClient.js** : This is the path to mxGraph library. If the HTML file is executed locally, the path might be local to the computer or a public Internet path. If the html page were downloaded from a web server, the path would generally be a public Internet path.

- **Creation of the container** : At the bottom of the code, in the body element, the function that is called on loading the web page is defined (the value of onload). It passes in a div container as a parameter, that is defined underneath. This div is the container the mxGraph component will be placed within. In this example a grid background is applied, as commonly used in diagramming applications. No other part of the graph visuals are described at container creation, other than the background and the container width and height.

  Note that the overflow:hidden style should always be used if you want no scrollbars to appear.

- **The entry function** : The main code of the file is the entry method executed on page load in this case. This is JavaScript code and must be within a JavaScript *script* element. The first lines of any mxGraph application should be to check the browser is supported and exit appropriately if not. If the browser is supported, a mxGraph is created within the div container and three cells are added to the graph between the begin/end update calls.

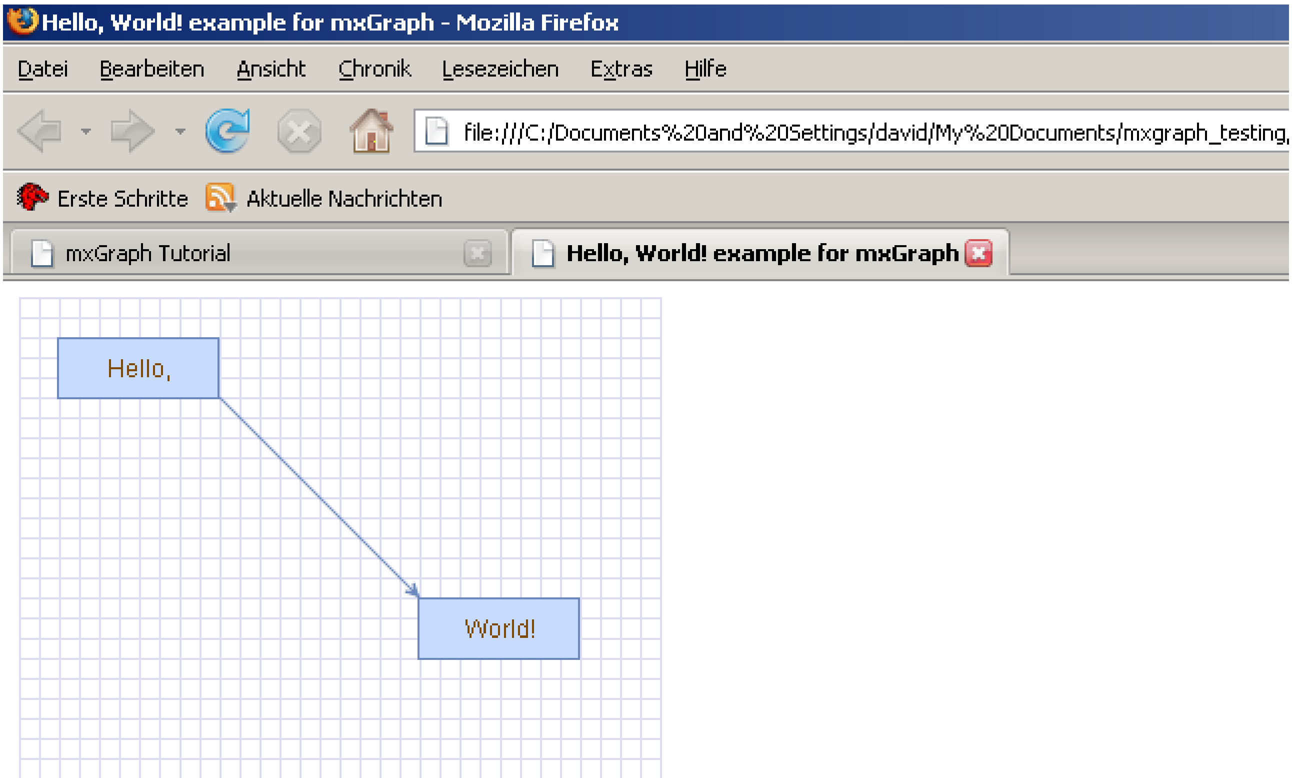


Illustration 7: The mxGraph HelloWorld example

```
<html>
<head>
	<title>Hello, World! example for mxGraph</title>

	<!-- Sets the basepath for the library if not in same directory -->
	<script type="text/javascript">
		mxBasePath = '../src/';
	</script>

	<!-- Loads and initializes the library -->
	<script type="text/javascript" src="../src/js/mxClient.js"></script>

	<!-- Example code -->
	<script type="text/javascript">
		// Program starts here. Creates a sample graph in the
		// DOM node with the specified ID. This function is invoked
		// from the onLoad event handler of the document (see below).
		function main(container)
		{
			// Checks if the browser is supported
			if (!mxClient.isBrowserSupported())
			{
				mxUtils.error('Browser is not supported!', 200, false);
			}
			else
			{
				// Creates the graph inside the given container
				var graph = new mxGraph(container);

				// Enables rubberband selection
				new mxRubberband(graph);

				// Gets the default parent for inserting new cells. This
				// is normally the first child of the root (ie. layer
0).
				var parent = graph.getDefaultParent();

				// Adds cells to the model in a single step
				graph.getModel().beginUpdate();
				try
				{
					var v1 = graph.insertVertex(parent, null,
						'Hello,', 20, 20, 80, 30);
					var v2 = graph.insertVertex(parent, null,
						'World!', 200, 150, 80, 30);
					var e1 = graph.insertEdge(parent, null, '', v1,
						v2);
				}
				finally
				{
					// Updates the display
					graph.getModel().endUpdate();
				}
			}
		};
	</script>
</head>

<!-- Page passes the container for the graph to the program -->
<body onload="main(document.getElementById('graphContainer'))">

	<!-- Creates a container for the graph with a grid wallpaper -->
```

```
      <div id="graphContainer"
style="overflow:hidden;width:321px;height:241px;background:url('editors/images/grid.gif')">
      </div>
</body>
</html>
```

Important concepts to note in this exercise are:

- mxClient.js is a JavaScript file combining all of the JavaScript source code of mxGraph. When downloading from a web server, obtaining all the JavaScript as one file is much faster than as lots of separate files, due to the overhead of the requests/acknowledgements required for each file. The speed increase is usually at least x2, although it varies with the capacity of the server to have parallel sockets open with one client.
- The JavaScript code and its dependencies are all placed within the *head* element.
- Internet Explorer has, by default, security options enabled that cause a user prompt when attempting to run JavaScript from the local file system. This can be disabled in the options menu, but note that running from the local file system is not a deployment scenario of mxGraph, this would only happen during development.
- Your application can be written and linked into the application either within the HTML file, or in separate JavaScript source code that is linked into the html in the way the mxClient.js file is in the example.

2.4 Notes on JavaScript download speed

The mxClient.js file is the entire JavaScript source to mxGraph, with all of the whitespace and comments removed to reduce file size. Whilst debugging, it is easier to use the individual source files if you need to debug into the mxGraph library itself. The full version of mxGraph contains the full source in the source.zip file in the javascript directory. Unzipping this into the mxBasePath and removing the load of the complete mxClient.js file enables easier debugging of the mxGraph library. Note that the mxclient.js file in the source zip is a bootstrap file that loads all the other JavaScript source code.

The download speed of the client source can be further improved by compressing the code. All modern browsers support receiving and uncompressing transmissions compressed at the server end and all good web servers support detection of those browser that do not support it and send the uncompressed version as a fall-back.

For example, on the Apache web server there is a mod_deflate module, details of its use can be found from a standard search. The mxGraph.com server uses this module and there have been no reports of issues in any supported browser.

The use of compression reduces the mxClient.js file size down from about 600KB to around 130KB. The difference is not noticed by the user on most modern networks, but there might be situations where the smaller version would be preferable.

3 mxGraph Model and Cells

3.1 Core mxGraph architecture

3.1.1 THE MXGRAPH MODEL

The mxGraph model is the core model that describes the structure of the graph, the class is called mxGraphModel and is found within the model package. Additions, changes and removals to and from the graph structure take place through the graph model API. The model also provides methods to determine the structure of the graph, as well as offering methods to set visual states such as visibility, grouping and style.

However, although the transactions to the model are stored on the model, mxGraph is designed in such a way that the main public API is through the mxGraph class. The concept of "add this cell to the graph" is a more natural description of the action than "add this cell to the model of the graph". Where it is intuitive, functions available on the model and cells are duplicated on the graph and those methods on the graph class are considered the main public API. Throughout the rest of this manual these key API methods are given a pink background:

anExampleCoreAPIMethod()

So, though many of the main API calls are through the mxGraph class, keep in mind that mxGraphModel is the underlying object that stores the data structure of your graph.

mxGraph uses a transactional system for making changes to the model. In the HelloWorld example we saw this code:

```
// Adds cells to the model in a single step
graph.getModel().beginUpdate();
try
{
     var v1 = graph.addVertex(parent, null, 'Hello,', 20, 20, 80, 30);
     var v2 = graph.addVertex(parent, null, 'World!', 200, 150, 80, 30);
     var e1 = graph.addEdge(parent, null, '', v1, v2);
}
finally
{
     // Updates the display
     graph.getModel().endUpdate();
}
```

to perform the insertion of the 2 vertices and 1 edge. For each change to the model you make a call to beginUpdate(), make the appropriate calls to change the model, then call endUpdate() to finalize the changes and have the change event notifications sent out.

Key API Methods:

mxGraphModel.beginUpdate() - starts a new transaction or a sub-transaction.
mxGraphModel.endUpdate() - completes a transaction or a sub-transaction.
mxGraph.addVertex() - Adds a new vertex to the specified parent cell.
mxGraph.addEdge() - Adds a new edge to the specified parent cell.

Note – Technically you do not have to surround your changes with the begin and end update calls. Changes made outside of this update scope take immediate effect and send out the notifications immediately. In fact, changes within the update scope enact on the model straight away, the update scope is there to control the timing and concatenation of event notifications. Unless the update wrapping causes code aesthetic issues, it is worth using it by habit to avoid possible problems with event and undo granularity.

Note the way in which the model changes are wrapped in a try block and the endUpdate() in a finally block. This ensures the update is completed, even if there is an error in the model changes. You should use this pattern wherever you perform model changes for ease of debugging.

Ignore the reference to the parent cell for now, that will be explained later in this chapter.

3.1.2 THE TRANSACTION MODEL

The sub-transaction in the blue block above refers to the fact that transactions can be nested. That is, there is a counter in the model that increments for every *beginUpdate* call and decrements for every *endUpdate* call. After increasing to at least 1, when this count reaches 0 again, the model transaction is considered complete and the event notifications of the model change are fired.

This means that every sub-contained section of code can (and should) be surrounded by the begin/end combination. This provide the ability in mxGraph to create separate transactions that be used as "library transactions", the ability to create compound changes and for one set of events to be fired for all the changes and only one undo created. Automatic layouting is a good example of where the functionality is required.

In automatic layouting, the user makes changes to the graph, usually through the user interface, and the application automatically positions the result according to some rules. The automatic positioning, the layouting, is a self-contained algorithm between begin/end update calls that has no knowledge of the specifics of the change. Because all changes within the begin/end update are made directly to the graph model, the layout can act upon the state of the model as the change is in progress.

It is important to distinguish between functionality that acts on the graph model as part of a compound change and functionality that reacts to atomic graph change events. In the first case, such as for automatic layouting, the functionality takes the model as-is and acts upon it. This method should only be used for parts of compound model changes. All other parts of the application should only react to model change events.

Model change events are fired when the last endUpdate call reduces the counter back down to 0 and indicate that at least one atomic graph change has occurred. The change event contains complete information as to what has altered (see later section on **Events** for more details).

3.1.2.1 The Model Change Methods

Below is a list of the methods that alter the graph model and should be placed, directly or indirectly, with the scope of an update:

```
    add(parent, child, index)
    remove(cell)
```

```
      setCollapsed(cell, collapsed)
      setGeometry(cell, geometry)
      setRoot(root)
      setStyle(cell, style)
      setTerminal(cell, terminal, isSource)
      setTerminals(edge,source,target)
      setValue(cell, value)
      setVisible(cell, visible)
```

Initially, we will just concern ourselves with the add and remove, as well as the geometry and style editing methods. Note that these are not core API methods, as usual these methods are on the mxGraph class, where appropriate, and they perform the update encapsulation for you.

Design Background - Some people are confused by the presence of visual information being stored by the model. These attributes comprise cell positioning, visibility and collapsed state. The model stores the default state of these attributes, providing a common place to set them on a per-cell basis, whereas, views can override the values on a per-view basis. The model is simply the first common place in the architecture where these attributes can be set on a global basis. Remember, this is a graph *visualization* library, the visualization part is the core functionality.

3.1.2.1.1 Inserting Cells

The three graph cells created in the `HelloWorld` application are two vertices and one edge connecting the vertices. If you are not familiar with basic graph theory and its terminology, please see the wikipedia entry.

You can add vertices and edges using the `add()` method on the model. However, for the purposes of general usage of this library, learn that `mxGraph.insertVertex()` and `mxGraph.insertEdge()` are the core public API for adding cells. The function of the model requires that the cell to be added is already created, whereas the `mxGraph.insertVertex()` creates the cell for you.

Core API functions:

mxGraph.insertVertex(parent, id, value, x, y, width, height, style) – creates and inserts a new vertex into the model, within a begin/end update call.
mxGraph.insertEdge(parent, id, value, source, target, style) – creates and inserts a new edge into the model, within a begin/end update call.

`mxGraph.insertVertex()` will create an mxCell object and return it from the method used. The parameters of the function are:

parent - the cell which is the immediate parent of the new cell in the group structure. We will address the group structure shortly, but for now use:

```
graph.getDefaultParent();
```

as your default parent, as used in the HelloWorld example.

id – this is a global unique identifier that describes the cell, it is always a string. This is primarily for referencing the cells in the persistent output externally. If you do not wish to maintain ids yourself, pass null into this parameter and ensure that `mxGraphModel.isCreateIds()` returns true. This way the model will manage the ids and ensure they are unique.

value – this is the user object of the cell. User object are simply that, just objects, but form the objects that allow you to associate the business logic of an application with the visual representation of mxGraph. They will be described in more detail later in this manual, however, to start with if you use a string as the user object, this will be displayed as the label on the vertex or edge.

x, y, width, height – as the names suggest, these are the x and y position of the top left corner of the vertex and its width and height.

style – the style description to be applied to this vertex. Styles will be described in more detail shortly, but at a simple level this parameter is a string that follows a particular format. In the string appears zero or more style names and some number of key/value pairs that override the global style or set a new style. Until we create custom styles, we will just use those currently available.

With the edge addition method, the identically named parameters perform the same function as in the vertex addition method. The source and target parameters define the vertices to which the edge is connected. Note that the source and target vertices should already have been inserted into the model.

3.1.3 MXCELL

mxCell is the cell object for both vertices and edges. mxCell duplicates many of the functions available in the model. The key difference in usage is that using the model methods creates the appropriate event notifications and undo, using the cell makes the change but there is no record of the change. This can be useful for temporary visual effects such as animations or changes on a mouse over, for example. As a general rule though, use the model editing API unless you encounter a specific problem with this mechanism.

When creating a new cell, three things are required in the constructor, a value (user object), a geometry and a style. We will now explore these 3 concepts before returning to the cell.

3.1.3.1 Styles

The concept of styles and stylesheets in conceptually similar to CSS stylesheets, though note that CSS are actually used in mxGraph, but only to affect global styles in the DOM of the HTML page. Open up the util.mxConstants.js file in your editor and search for the first match on "STYLE_". If you scroll down you will see a large number of strings defined for all the various styles available with this prefix. Some of styles apply to vertices, some to edges and some to both. As you can see, these define visual attributes on the element they act upon.

The mxStylesheet holds one object, styles, which is a hashtable mapping style names to an array of styles:

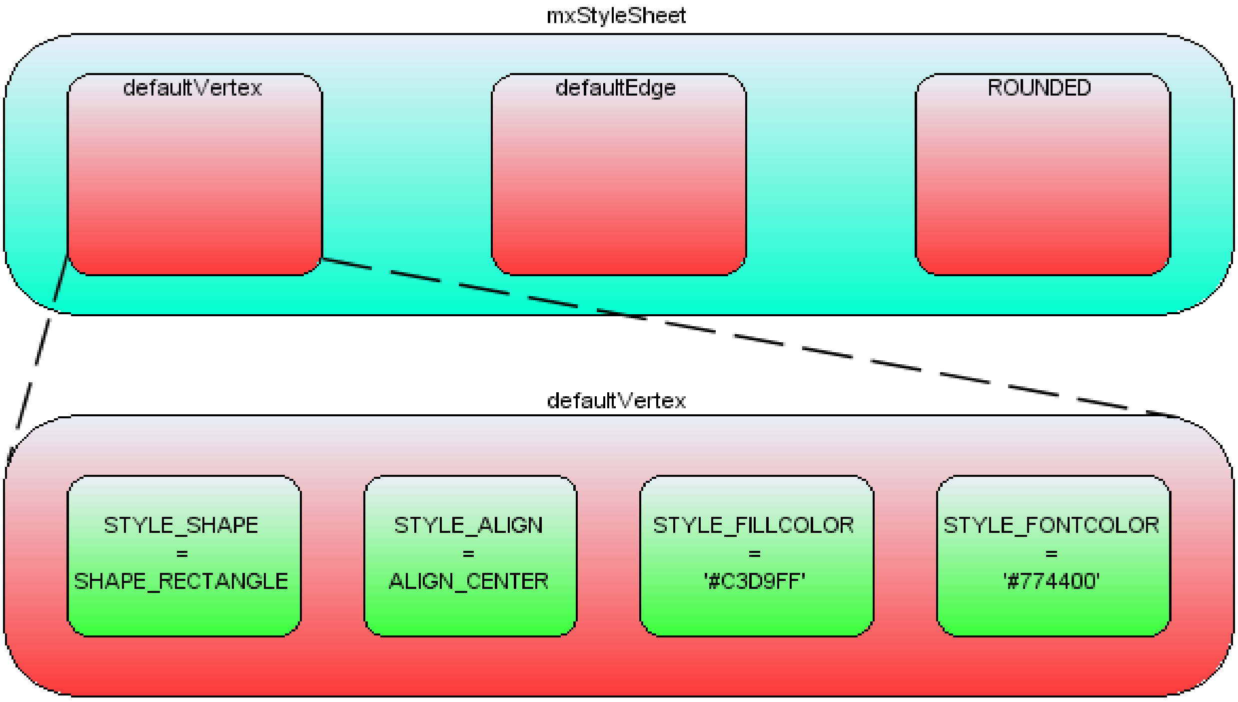


Illustration 8: Style arrays within the styles collection

In the above image the blue box represents the styles hashtable in `mxStyleSheet`. The string 'defaultVertex' is the key to an array of string/value pairs, which are the actual styles. Note that mxGraph creates two default styles, one for vertices and one for edges. If you look back to the helloworld example, no style was passed into the optional style parameter of `insertVertex` or `insertEdge`. In this case the default style would be used for those cells.

3.1.3.1.1 Setting the Style of a Cell

If you wanted to specify a style other than the default for a cell, you must pass that new style either to the cell when it is created (`mxGraph's insertVertex` and `insertEdge` both have an optional parameter for this) or pass that style to the cell using `model.setStyle()`.

The style that you pass has the form `[stylename;|key=value;]`. ,note that the stylenames and key/value pairs may be in any order. Below are examples to demonstrate this concept, adapting the insertVertex call we saw in helloworld:

1. A new style called 'ROUNDED' has been created, to apply this to a vertex:

```
    var v1 = graph.insertVertex(parent, null, 'Hello',  20, 20, 80, 30,
'ROUNDED');
```

2. To create a new vertex with the ROUNDED style, overriding the stroke and fill colors:

```
    var v1 = graph.insertVertex(parent, null, 'Hello',  20, 20, 80, 30,
'ROUNDED;strokeColor=red;fillColor=green');
```

3. To create a new vertex with no global style, but with local stroke and fill colors:

```
    var v1 = graph.insertVertex(parent, null, 'Hello',  20, 20, 80, 30,
';strokeColor=red;fillColor=green');
```

4. To create a vertex that uses the defaultVertex style, but a local value of the fill color:

```
    var v1 = graph.insertVertex(parent, null, 'Hello',  20, 20, 80, 30,
'defaultVertex;fillColor=blue');
```

Note that default style must be explicitly named in this case, missing the style out sets no global style on the cell when the semi-colon starts the string. If the string starts with no semi-colon, the default style is used.

Again, the mxGraph class provides utility functions that form the core API for accessing and changing the styles of cells:

Core API functions:

mxGraph.setCellStyle(style, cells) – Sets the style for the array of cells, encapsulated in a begin/end update.

mxGraph.getCellStyle(cell) – Returns the style for the specified cell, merging the styles from any local style and the default style for that cell type.

3.1.3.1.2 Creating a New Global Style

To create the ROUNDED global style described above, you can follow this template to create a style and register it with mxStyleSheet:

```
    var style = new Object();
    style[mxConstants.STYLE_SHAPE] = mxConstants.SHAPE_RECTANGLE;
    style[mxConstants.STYLE_OPACITY] = 50;
    style[mxConstants.STYLE_FONTCOLOR] = '#774400';
    graph.getStylesheet().putCellStyle('ROUNDED', style);
```

3.1.3.2 Geometry

In the helloworld example we saw the position and size of the vertices passed into the insertVertex function. The coordinate system in JavaScript is x is positive to the right and y is positive downwards, and in terms of the graph, the positioning is absolute to the container within which the mxGraph is placed.

The reason for a separate mxGeometry class, as opposed to simply having the mxRectangle class store this information, is that the edges also have geometry information.

The width and height values are ignored for edges and the x and y values relate to the positioning of the edge label. In addition, edges have the concept of control points. These are intermediate points along the edge that the edge is drawn as passing through. The use of control points is sometimes referred to as **edge routing**.

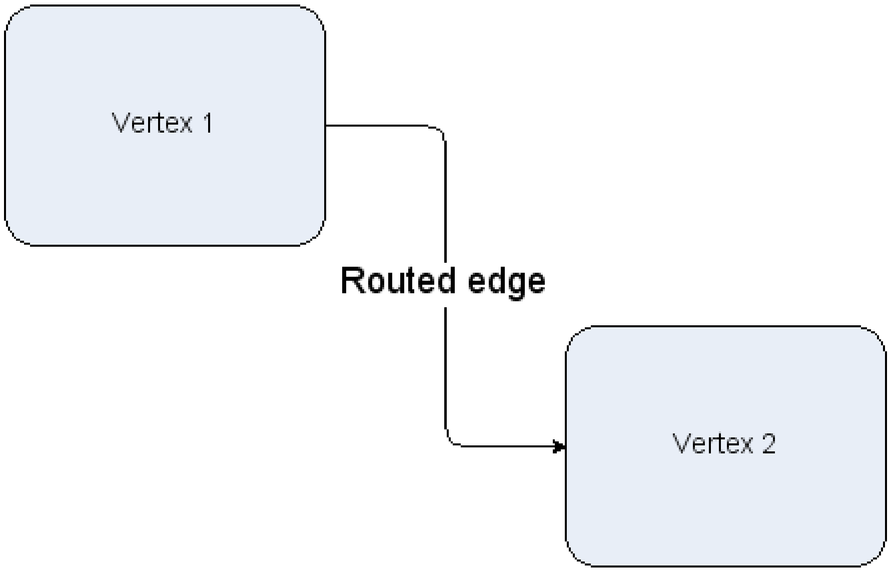


Illustration 9: An edge routed by 2 control points

There are two more important additional concepts in geometry, relative positioning and offsets

3.1.3.2.1 Relative Positioning

By default, the x and y position of a vertex is the offset of the top left point of the bounding rectangle of the parent to the top left point of the bounding rectangle of the cell itself. The concept of parents and groups is discussed later in this chapter, but without going into too much detail, if a cell does not have cell parent, the graph container is its parent for positioning purposes.

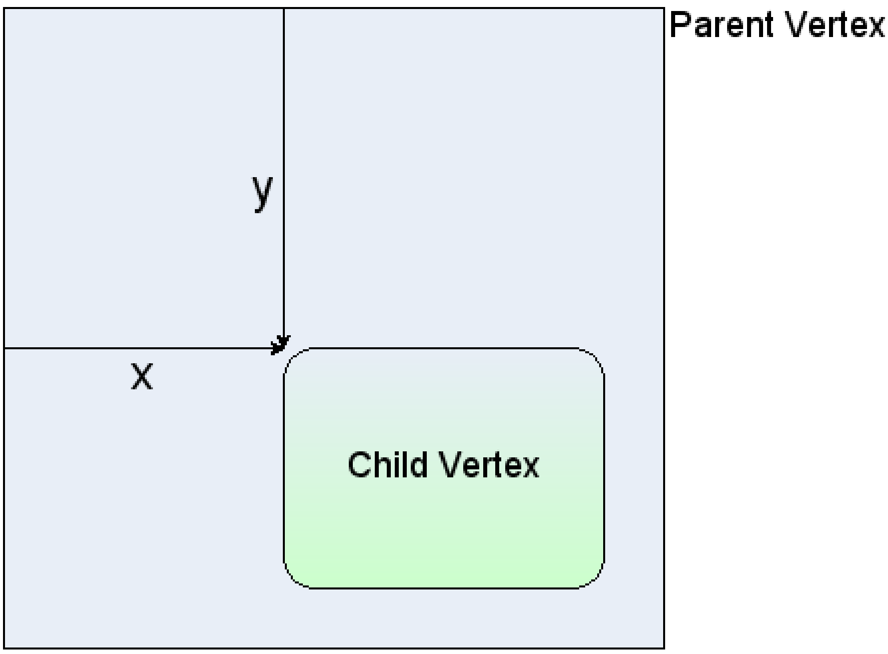


Illustration 10: Non-relative vertex positioning

For an edge, in non-relative mode, which is the default mode, the edge label position is the absolute offset from the graph origin.

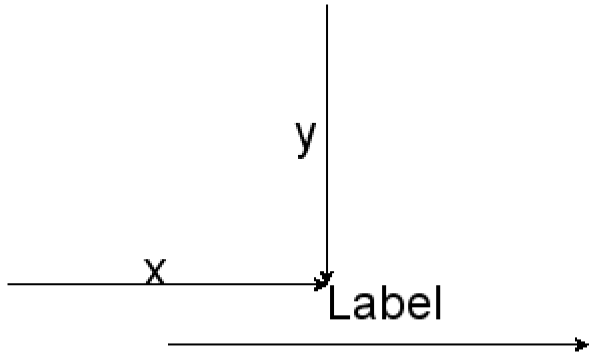


Illustration 11: Non-relative edge label positioning

For vertices in relative mode, (x,y) is the proportion along the parent cell's (width, height) where the cell's origin lies. (0,0) is the same origin as the parent, (1,1) places the origin at the bottom right corner of the parent. The same relative positioning extends below 0 and above 1 for both dimensions. This positioning is useful for keeping child cells fixed relative to the overall parent cell size.

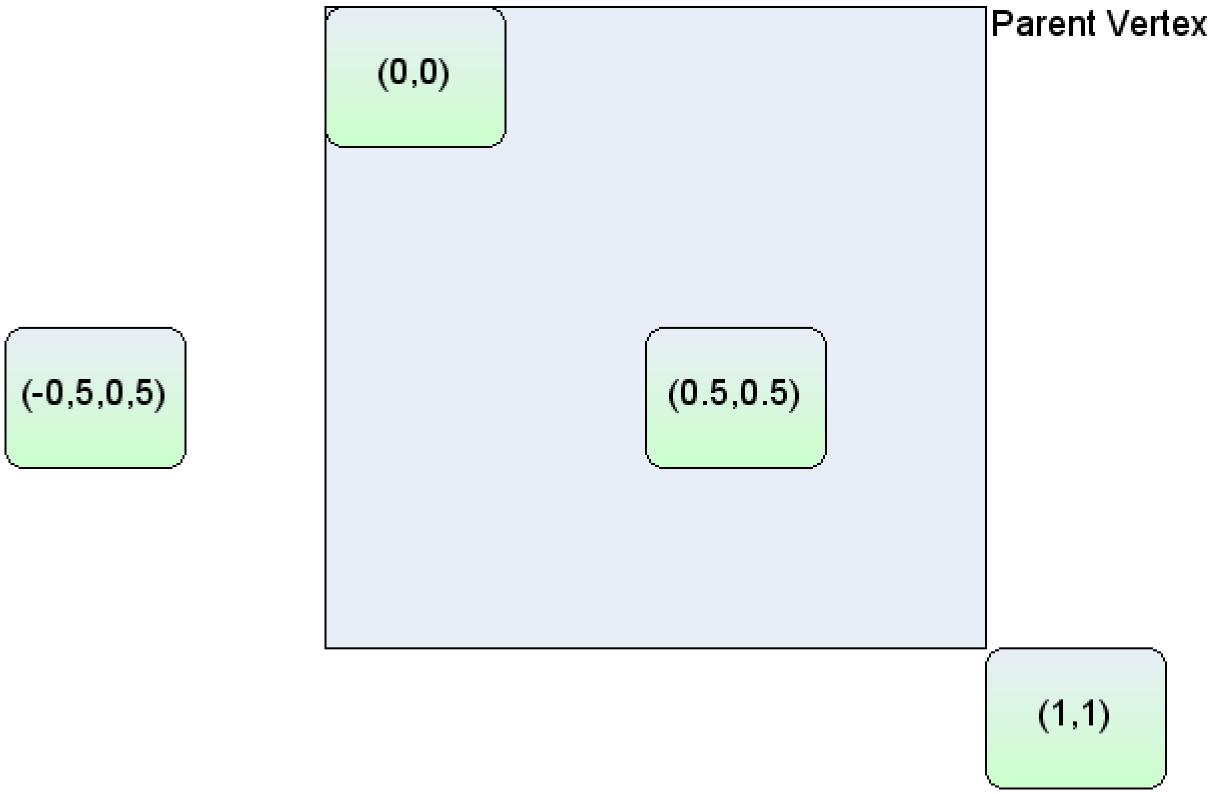


Illustration 12: Relative vertex positions

Lastly, edge labels in relative mode are placed based on the positioning from the center of the edge. The x-coordinate is the relative distance from the source end of the edge, at -1, to the target end of the edge, at 1. The y co-ordinate is the pixel offset orthogonal from the edge. The diagram below shows the values of x,y for various edge labels in relative mode. Note that for a straight edge, the calculations are simple. For edges with multiple control points, the edge has to be traced along its segments (a segment being the line between end points and/or control points) to find the correct distance along the edge. The y value is the orthogonal offset from that segment.

Switching relative positioning on for edge labels is a common preference for applications. Navigate to the `mxGraph.insertEdge()` function in `mxGraph`, you will see this calls `createEdge()`. In `createEdge()` the geometry is set relative for every edge created using this prototype. This is partly the reason for the amount of helper functions in mxGraph, they enable easy changing of the default behaviour. You should try to use the mxGraph class API as much as possible to provide this benefit in your applications.

3.1.3.2.2 Offsets

The offset field in mxGeometry is an absolute x,y offset applied to the cell **label**. In the case of edge labels, the offset is always applied after the edge label has been calculated according to the relative flag in the above section.

Core API functions:

mxGraph.resizeCell(cell, bounds) – Resizes the specified cell to the specified bounds, within a begin/end update call.
mxGraph.resizeCells(cells, bounds) – Resizes each of the cells in the cells array to the corresponding entry in the bounds array, within a begin/end update call.

3.1.3.3 User Objects

The User object is what gives mxGraph diagrams a context, it stores the business logic associated with a visual cell. In the `HelloWorld` example the user object has just been a string, in this case it simply represents the label that will be displayed for that cell. In more complex applications, these user objects will be objects instead. Some attribute of that object will generally be the label that the visual cell will display, the rest of the object describes logic relating to the application domain.

Using the example of a simple workflow or process application, say we have the graph below (this example is available online, select the Swimlanes example from the tasks window):

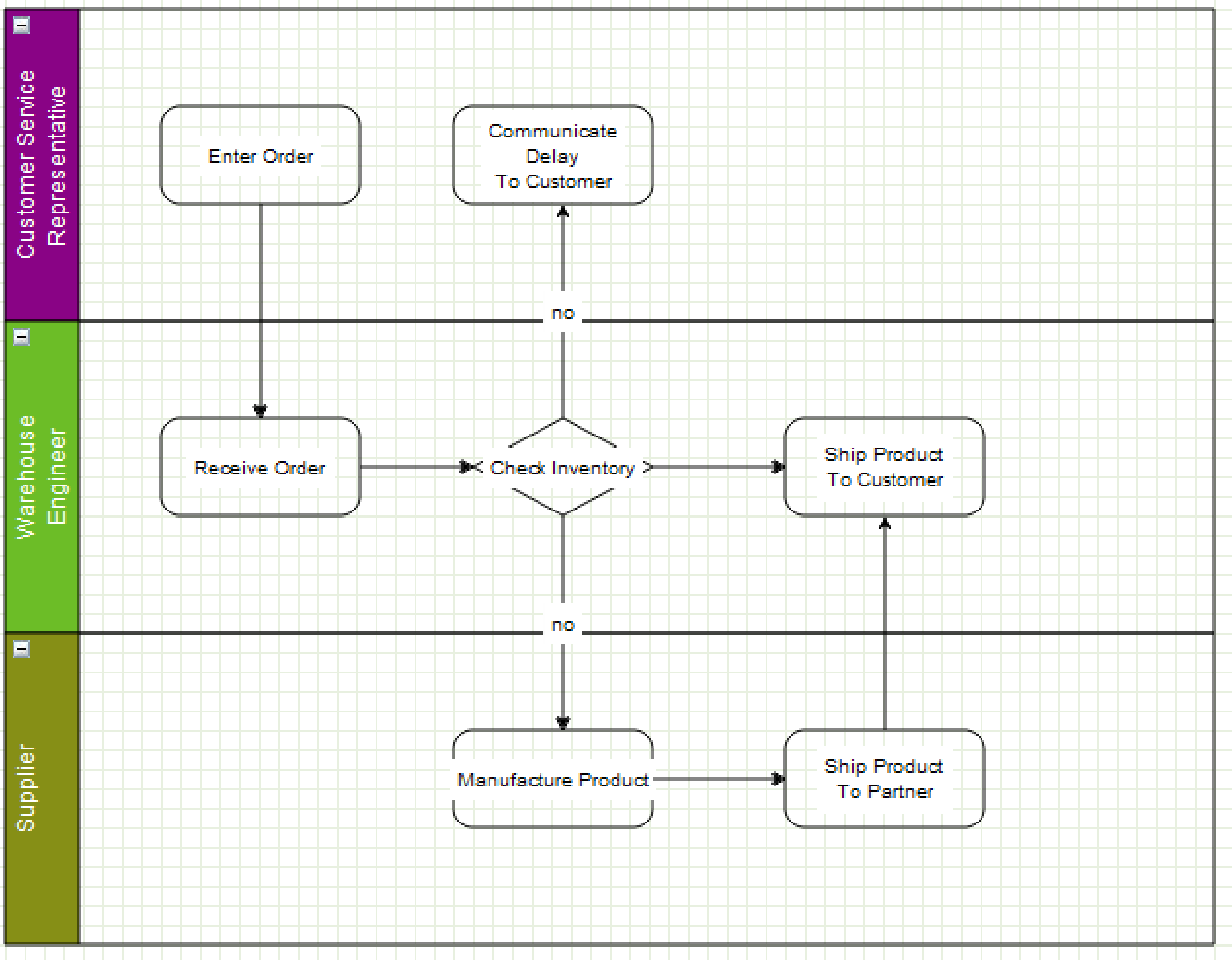


Illustration 13: A simple workflow

Typically, this workflow will exist on some application server and/or database. The browser user connects to that server, or some front-end server linked to the application server and the user's web application requests the "order" workflow. The server obtains the data of that workflow and transmits it to the client.

mxGraph supports the process of populating the model on the server-side and transmitting to the client, and back again. See the later chapter on "I/O and Server Communication".

The data transmitted will be both the visual model (the diagram) as well as the business logic (mostly contained in the user objects). The client will initially show the diagram above. If the user has permission to edit this workflow they will normally be able to do two things, 1) edit the diagram, add and remove vertices, as well as changing the connections, and 2) edit the user objects of the cells (vertices and/or edges).

In the online demo, if you right click and select properties of the "Check Inventory" diamond you will see this dialog:

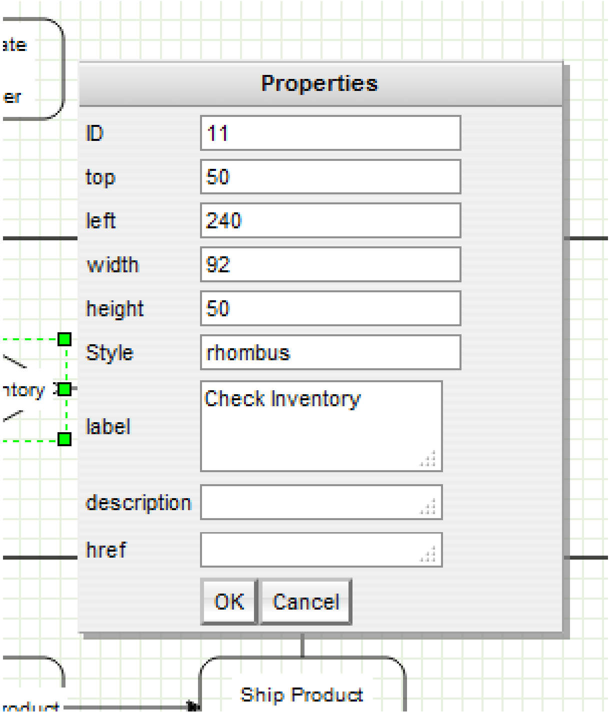


Illustration 14: The properties of a vertex

These properties show the geometry, label, ID etc, but a dialog could just as easily show the user object of the cell. There might be a reference to some process on the workflow engine as to how the inventory is actually checked. This might be an application specific mechanism for both the server and client to assign some identification to remote method calls. Another value might be the type of object that process returned, maybe a boolean or an integer to indicate stock level in this case. Given that return type, it is possible to enforce constraints with the diagram and provide visual alerts of if, say, the outgoing edges decision check does not correspond to the return type of the vertex.

Next, as an example, the user objects of the outgoing edges might contain a label and a boolean state. Again, the mxGraph-based editor might provide the means to alter the boolean value. On the server, when executing the process, it might follow the edges that correspond to the boolean value returned by the decision node.

Keep in mind that the above example is very domain specific, it is there to explain how the user object maps to the business logic of the application. It visualizes how mxGraph creates what we term a **contextual graph**. The context is formed by the connections between vertices and the business logic stored within the user objects. A typical application receives the visual and business logic from a sever, may allow editing of both, then transmits both back to the server for persistence and/or execution.

3.1.3.4 Cell Types

As described previously, mxGraph is the primary API for using this library and the same concept applies to cells. One basic state of the cell not exposed on the graph is whether a cell is a vertex or an edge, this call be performed on the cell or on the model.

There are two boolean flags on mxCell, vertex and edge, and the helper methods set one of these to true when the cell is created. `isVertex()`, `isEdge()` on `mxIGraphModel` are what the model uses to determine a cell's type, there are not separate objects for either type. Technically, it is possible to switch the type of a cell at runtime, but take care to invalidate the cell state (see later section) after changing the type. Also, be aware that the geometry object variable means different things to vertices and edges. Generally, it is not recommended to change a cell type at runtime.

3.1.4 GROUP STRUCTURE

Grouping, within mxGraph, is the concept of logically associating cells with one another. This is commonly referred to as the concept of sub-graphs in many graph toolkits. Grouping involves one or more vertices or edges becoming children of a parent vertex or edge (usually a vertex) in the graph model data structure. Grouping allows mxGraph to provide a number of useful features:

- Sub-graphs, the concept of a logically separate graph that is displayed in the higher level graph as a cell per sub-graph.
- Expanding and collapsing. Collapsing is the ability to replace a collection of grouped cells visually with just their parent cell. Expanding is the reverse of this. This behaviour can be seen by clicking the small "-" in the top left corner of the group cells of the swimlanes example in the online workfloweditor example. This is described in the C*omplexity Management* section below.
- Layering. Layering is the concept of assigning cells to a particular z-order layer within the graph display.
- Drill down, step up. These concepts allow sub-graphs to be visualized and edited as if they are a complete graph. In the U*ser Objects* section we saw the "check inventory" vertex as a single cell. Take, for example, the case where a developer is describing each of the vertices in the process as the software processes that perform the task. The application might have an option to drill down into the check inventory vertex. This would result in a new graph appearing that describes in detail how exactly the system checks the inventory. The graph might have the title of the parent "check inventory" vertex to indicate it is a child, as well as the option to step-up back to the next level up.

In grouping, cells are assigned a parent cell. In the simplest case, all cells have the default parent as their parent. The default parent is an invisible cell with the same bounds as the graph. This is the cell returned by graph.getDefaultParent() in the helloworld example. The x,y position of a vertex is its position relative to its parent, so in the case of default grouping (all cells sharing the default parent) the cell positioning is also the absolute co-ordinates on the graph component. In the case all cells being added to the default root, the group structure logically looks like, in the case of the helloworld example, the diagram below.

Note the addition of the Layer 0 cell, this is the default indirection in the group structure that allows layer changes with the requirement of additional cells. We include it below for correctness, but in later group diagrams it will be omitted.

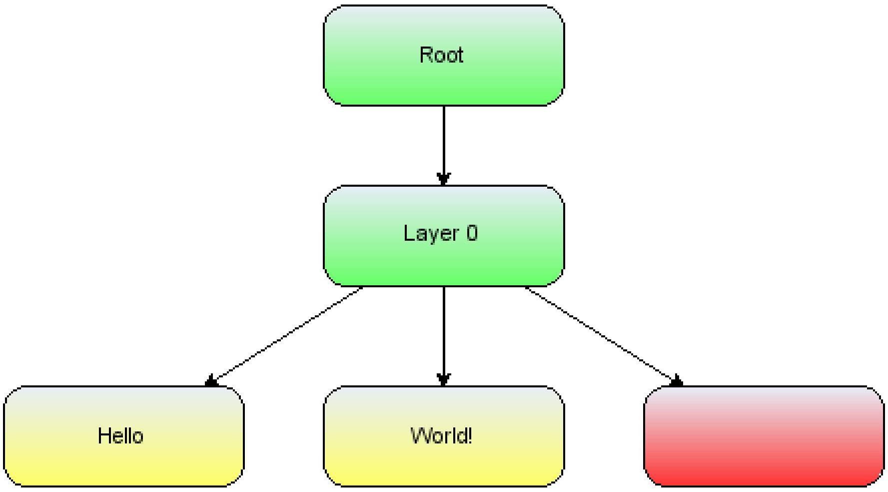


Illustration 15: The group structure of the helloworld example

Also, note that the position of the edge label (x,y in geometry) is relative to the parent cell.

If we go back to the simple workflow example in the User Objects section, we can see what grouping might look like visually. In the example the group cells represent people and the child vertices represent tasks assigned to those people. In this example the logical group structure looks like this:

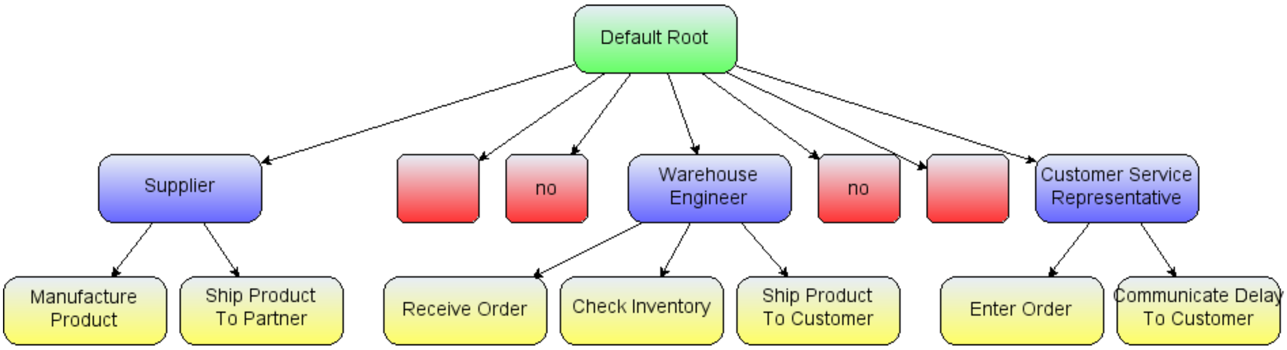


Illustration 16: The logical group structure of the workflow example

The workflow action vertices are the yellow children and the swimlane group vertices are marked blue.

Inserting cells into the group structure is achieved using the parent parameter of the `insertVertex` and `insertEdge` functions on the `mxGraph` class. These functions set the parent cell on the child accordingly and, importantly, informs the parent cell of its new child.

Altering the group structure is performed via the `mxGraph.groupCells()` and `mxGraph.ungroupCells()` functions.

Core API functions:

mxGraph.groupCells(group, border, cells) – Adds the specified cells to the specified group, within a begin/end update

mxGraph.ungroupCells(cells) – Removes the specified cells from their parent and adds them to their parent's parent. Any group empty after the operation are deleted. The operation occurs within a begin/end update.

3.1.5 COMPLEXITY MANAGEMENT

There are two primary reasons to control the number of cells displayed at any one time. The first is performance, drawing more and more cells will reach performance usability limits at some point on any platform. The second reason is ease of use, a human can only comprehend a certain amount of information. All of the concepts associated with grouping, listed in 3.1.4, can be used to reduce the complexity of information on the screen for the user.

3.1.5.1 Folding

Folding is the collective term we use for expanding and collapsing groups. We say a cell is folded by making it's child vertices invisible. There are a number of functions relating to this feature:

Core API function:

mxGraph.foldCells(collapse, recurse, cells) – States the collapsed state of the specified cells, within a begin/end update.

Folding related functions:

mxGraph.isCellFoldable(cell, collapse) – By default true for cells with children.
mxGraph.isCellCollapsed(cell) – Returns the folded state of the cell

When a group cell is collapsed, three things occur by default:

- The children of that cell become invisible.
- The group bounds of the group cell is used. Within `mxGeometry` there is a `alternativeBounds` field and in groups cells, by default store a separate bounds for their collapsed and expanded states. The switch between these instances is invoked by `mxGraph.swapBounds()` and this is handled for you within a `foldCells()` call. This allows collapsed groups to be resized whilst when expanded again the size looks correct using the pre-collapsed size.
- Edge promotion occurs, by default. Edge promotion means displaying edges that connect to children within the collapsed group that also connect to cells outside of the collapsed group, by making them appear to connect to the collapsed parent.

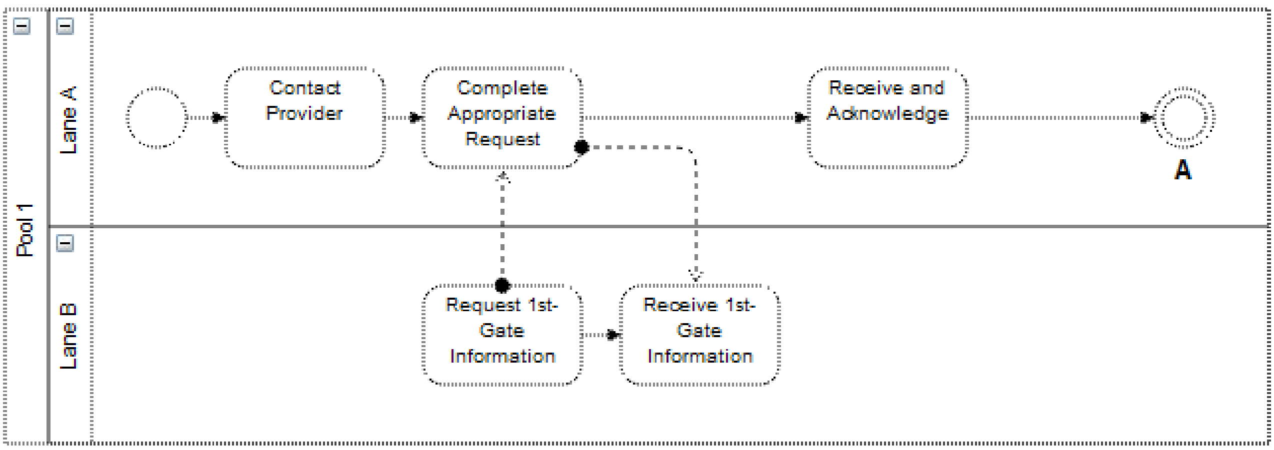


Illustration 17: Expanded swimlane

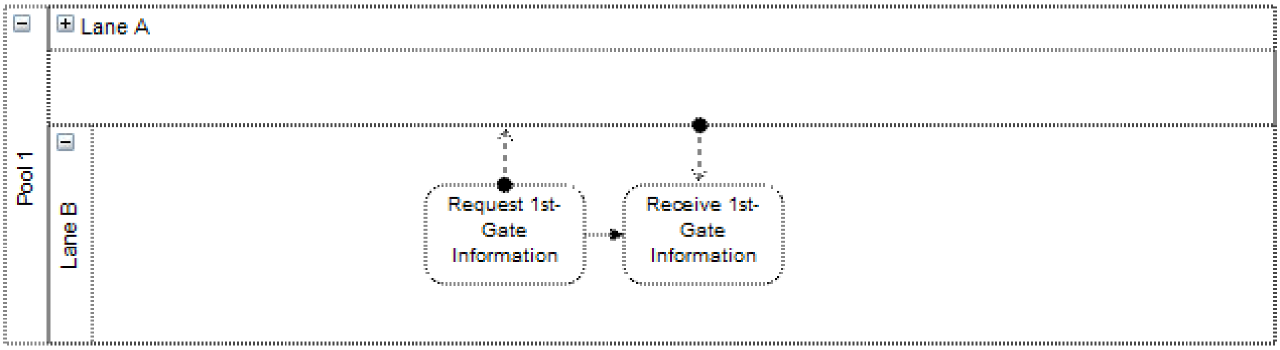


Illustration 18: Collapsed Swimlane

The above two images demonstrate these three concepts. In its expanded state the upper group cell displays a small box in the top left hand corner with a "-" character inside. This indicates that clicking on this box collapses the group cell. Doing this we get the bottom image where the group cell takes on its collapsed size. Child vertices and edge that do not leave the group cell are made invisible. Finally, edges that exit the group cell are promoted to appear to be connected to the collapsed group cell. Clicking on the "+" character that now appears within the box expands the group cell and brings it back to its original state of the top image.

Using the `mxGraph.foldCells()` function, you can achieve the same result programmatically as clicking on the expand/collapse symbols. One common usage of this is when the application zooms out a specific amount, clusters of cells are grouped and the grouped cell collapsed (very often without the "-" box since the application is controlling the folding). This way fewer, larger cells are visible to the user, each one representing their children cells logically. You might then provide a mechanism to zoom into a group, which expands it in the process. You might also provide drill-down/step-up, explained next.

3.1.5.2 Sub-Graphs, Drill-Down / Step-Up

Sometimes, as an alternative to expand/collapse, or possibly in combination with it, your graph will be composed of a number of graphs, nested into a hierarchy. Below we see a simple example:

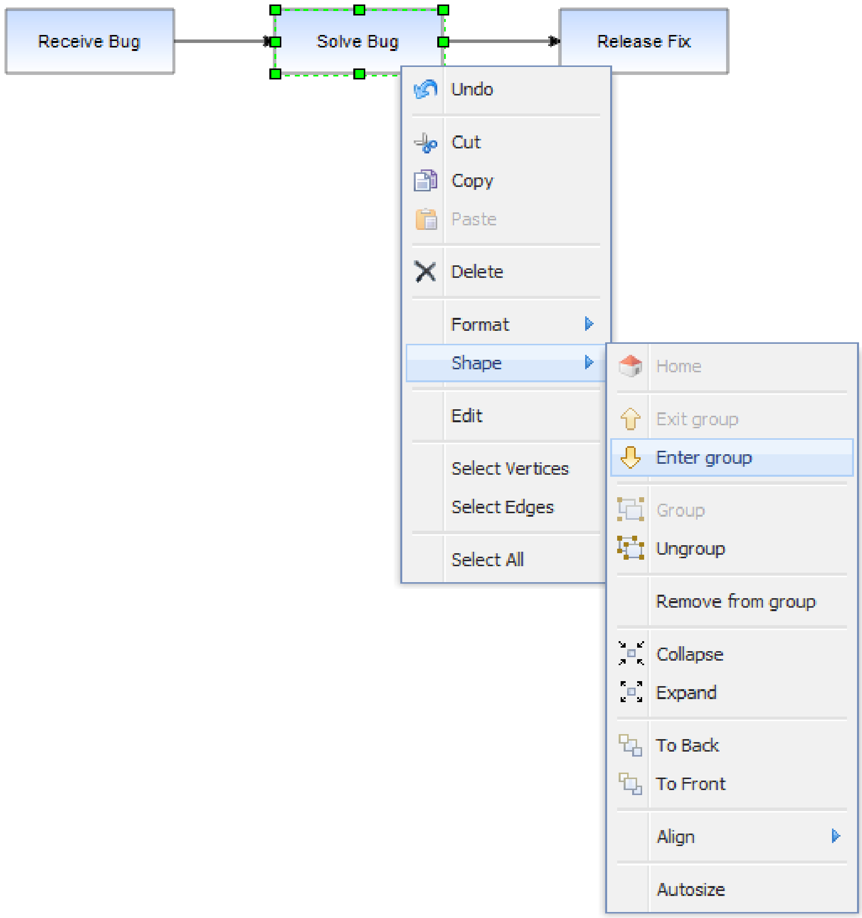


Illustration 19: An example top level workflow

This simple workflow consists of three high level steps. Obviously, the individual steps contain a number of sub-steps and we will look at a sub-graph of the *Solve Bug* cell.

Under the *Solve Bug* vertex we have created a number of children to represent the process of solving a bug in more detail, in this case the process of solving a bug on the Starship Enterprise.

In this example, which uses the GraphEditor example, the menu option shown selected in the above image invokes `mxGraph.enterGroup(cell)`, which is one of the pair of core API functions for sub-graphs.

Core API functions:

mxGraph.enterGroup(cell) – Makes the specified cell the new root of the display area.
mxGraph.exitGroup() - Makes the parent of the current root cell, if any, the new root cell.
mxGraph.home() - Exits all groups, making the default parent the root cell.

The root cell of the graph has been, up to now, the default parent vertex to all first-level cells. Using these functions you can make any group cell in the group structure the root cell, so that the children of that parent appear in the display as the complete graph.

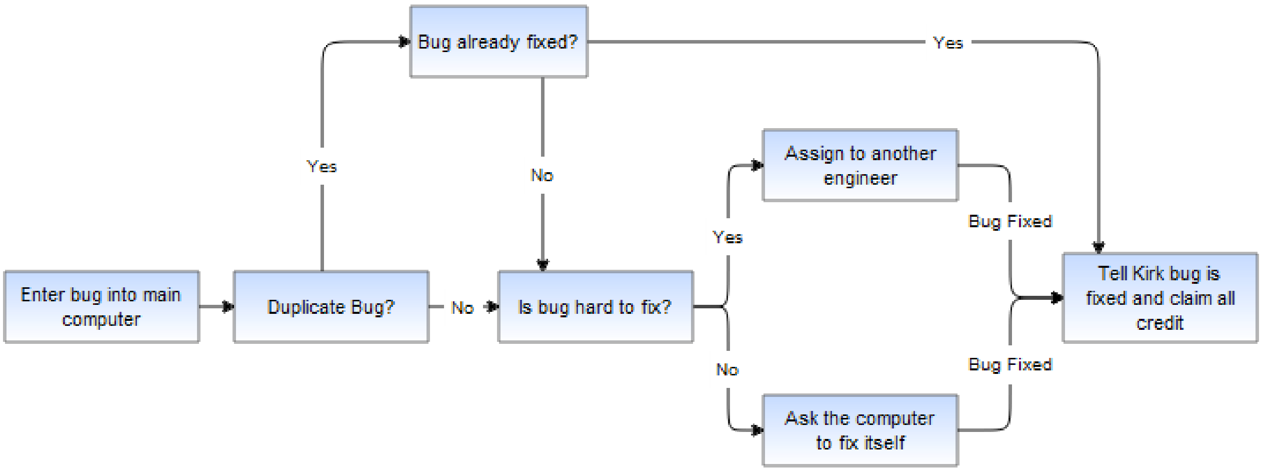
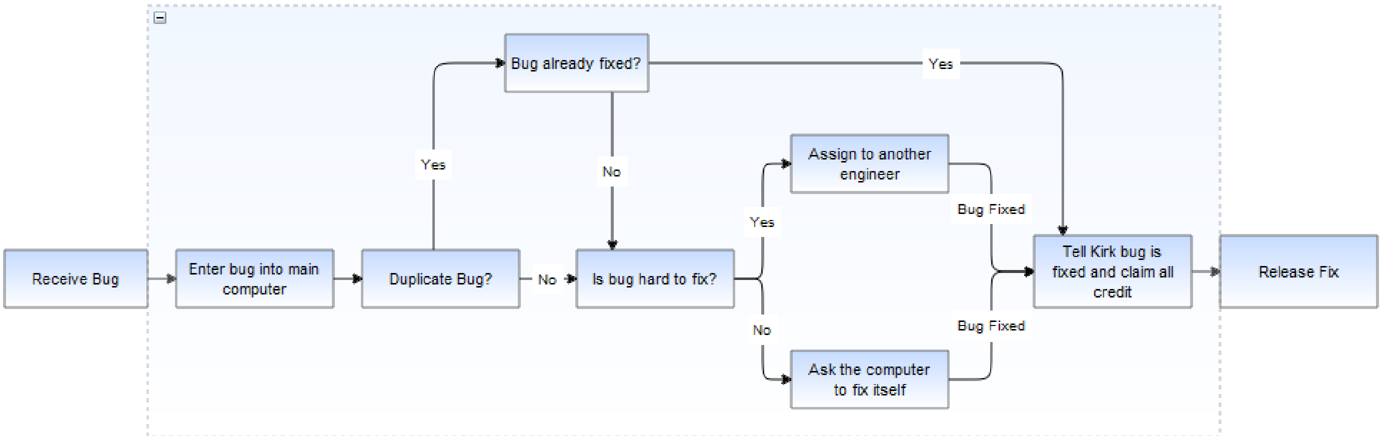


Illustration 20: Result of drilling down into the Solve Bug vertex

The same graph expanded using folding instead looks like:



Exiting the group using the *shape->exit group* option, which invokes `mxGraph.exitGroup`, brings you back to the original 3 vertex top level graph.

3.1.5.3 Layering and Filtering

In mxGraph, like many graphical applications, there is the concept of z-order. That is, the order of objects as you look into the screen direction. Objects can be behind or in front of other objects and if they overlap and are opaque then the back-most object will be partially or complete obscured. Look back to the graph structure of the HelloWorld example in Illustration 15. Children cells are stored under parents in a deterministic order (by default the order in which you add them).

If we move the cells in the HelloWorld example we see the following result:

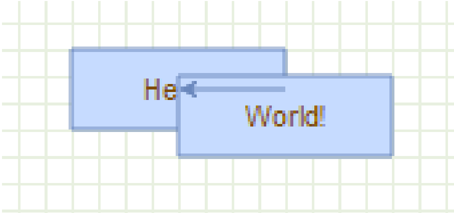


Illustration 21: Overlapped vertices

It can be seen that the *World* vertex is in front of the *Hello* vertex. This is because the *World* vertex has a higher child index than the *Hello* vertex, at positions 1 and 0 respectively in the ordered collection that holds the children of the root cell.

To change order we use mxGraph.orderCells.

Core API function:

mxGraph.orderCells(back, cells) – Moves the array of cells to the front or back of their siblings, depending on the flag, within a begin/end update.

A sibling cell in mxGraph is any cell that shares the same parent. So by invoking this on the *Hello* vertex it would then overlap the *World* Vertex.

Ordering and grouping can be extended to form logically layered groups. The cells are drawn via a depth-first search. Take the `HelloWorld` example again and imagine that both the *Hello* and *World* vertices have some hierarchy of children underneath them. The *Hello* vertex and all of its children will be drawn before the *World* vertex or any of its children. If *Hello* and *World* were invisible group cells you then have two hierarchies of cells, one being drawn entirely before the other. You can also switch the order of the hierarchies by simply switching the order of the invisible group cells.

The concept of layering is demonstrated in the layers.html example. Here buttons are used to set the visibility of group layer cells. This example ties very closely into the concept of filtering.

In filtering cells with some particular attribute are displayed. One option to provide filtering functionality is to check some state before rendering the cells. Another method, if the filtering conditions are simple and known in advance, is to assign filterable cells by groups. Making the groups visible and invisible performs this filtering operation.