

# JSFS - Unlimited JavaScript Access to Computer Resources without Browser Plugins

**Abstract:** JSFS provides a secure solution to access computer resources by JavaScript on web pages of enterprise applications. It does not make use of a browser plugin technology (e.g. ActiveX or Java Applet), and it does not claim to reduce browser security settings.

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# 1 Architectural Overview

## 1.1 The Problem

For security reasons, the JavaScript in web browsers allows only restricted access to computer resources. E.g. it is not possible to store files in an arbitrary folder, start applications or communicate with a USB device. Browser Plugins can be used in order to achieve extended access to computer resources. They can be written as Java Applets, ActiveXes, Flash Player or Silverlight applications. But enabling this technologies in the browser configuration reduce the security and that is why their usage is often forbidden in enterprise environments.

## 1.2 The Solution

Abbildung 1 shows an architectural overview of the JSFS solution. On the client side, the web browser shows the web pages sent from “Your Web Application”, the web application that requires access to resources on the client computer. Also installed on the client computer, a JSFS Agent application is running which has access to the desired resources. It has an open long-poll request to the JSFS Dispatcher on the server. The dispatcher service acts as a broker between the browser and the agent.

If JavaScript code acquires access to a computer resource, it sends a request to the JSFS Dispatcher which forwards the request to the JSFS Agent by responding to its long-poll request. The result is returned back to the JSFS Dispatcher by the next long-poll from the JSFS Agent. On receiving the long-poll, the JSFS web service passes the result to the primary JavaScript request.

It is also possible to use the reverse communication direction, whereby the JSFS Agent triggers JavaScript code in the Browser. This can be useful e.g., if the JSFS Agent has to watch a folder. When a new file is inserted, the JSFS Agent notifies the JavaScript code which in turn can notify “Your Web Application”.

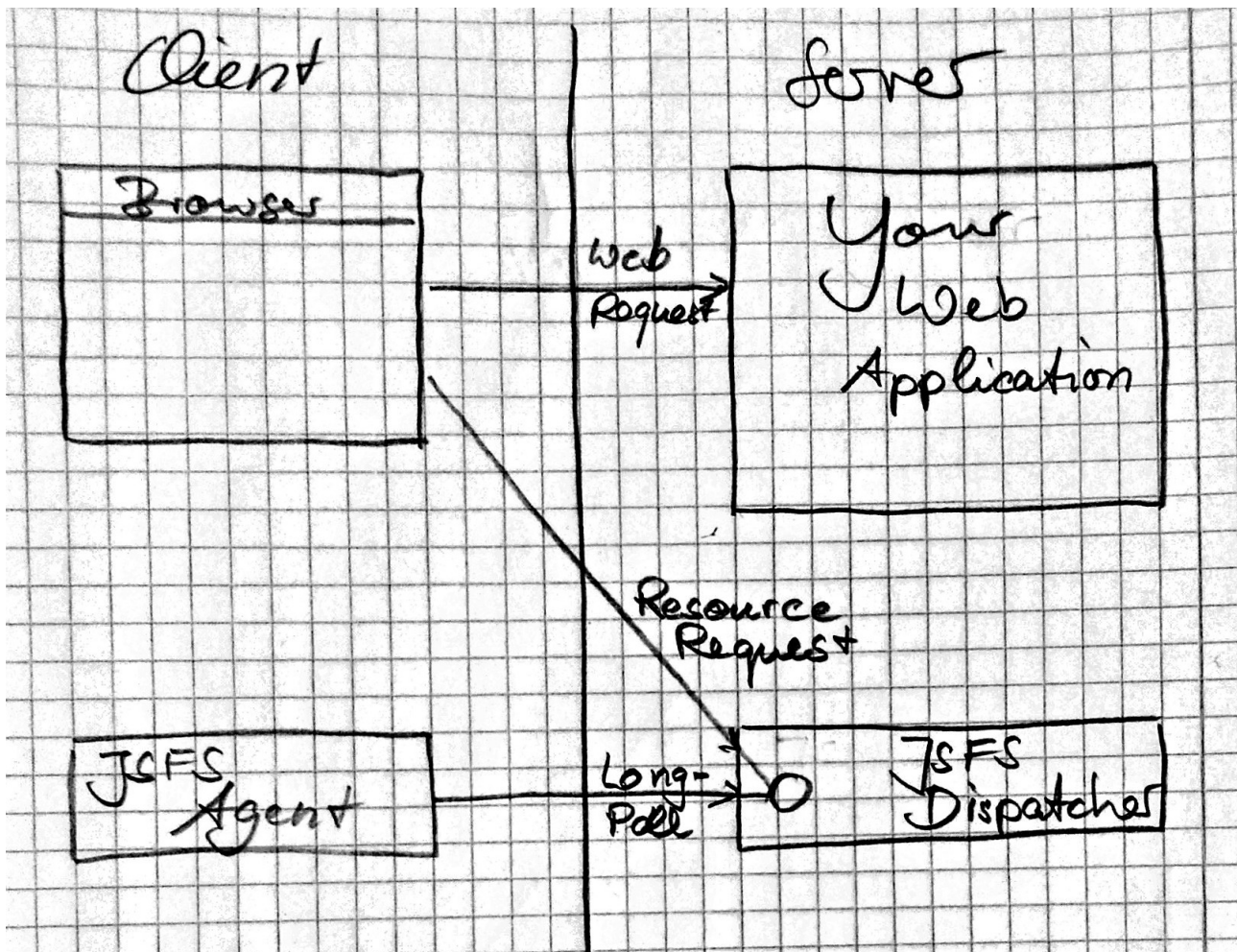


Abbildung 1: Architectural Overview

## 1.3 Field of Use

### 1.3.1 Focus on Enterprise Applications

One should be aware of the fact that all communication between the browser and JSFS Agent is sent over the network and through JSFS Dispatcher. For this reason, JSFS is rather a solution for applications running on a LAN than applications using internet connections or a cell phone network. But JSFS could even provide an acceptable user experience for mobile or internet applications, if the transferred amount of data and the number of requests are kept small.

The development targets are aimed at companies:

- reliable security
- ease of deployment
- low system requirements
- simple extendability
- acceptable performance

### 1.3.2 JSFS is Provided as Starting Point to be Extended

The JSFS solution is provided with full source code that can be modified to fit special requirements. For developing a JSFS Agent, starter examples in Java and C++ (MSVC 2012) are provided. They can be easily extended with additional functions or service interfaces.

### 1.3.3 Examples

The JSFS Agent allows to perform the following tasks within web pages:

- Watch directories
- Start an application in order to edit a document, get notified when the user has finished.
- Encrypt or digitally sign a document before it is uploaded to the server <sup>(\*)</sup>
- Control hardware devices like scanners, printers, card readers, etc. <sup>(\*)</sup>
- Check software protection dongles <sup>(\*)</sup>
- Control the web page by speech, or particular devices <sup>(\*)</sup>

<sup>(\*)</sup> Requires to extend the JSFS Agent, this functionality is not included in the supplied example implementation.

### 1.3.4 Cannot show UI on Web Page

The JSFS Agent cannot show a user interface component integrated in a web page. However, it might have views and allow user interaction, like any other program running on the client computer.

## 1.4 Code Example

The following example tries to give an idea of how to work with the JSFS solution in JavaScript code.

The example in Abbildung 2 shows the JavaScript function “listMyDocuments” that lists the files in the folder “My Documents” on a Windows computer. The JSFS Agent is represented by the object “jsfs” which provides the function “findFiles” for listing the files and sub directories of a folder. It sends a resource request to the JSFS Agent and returns its results synchronously.

Here, the “findFiles” function is fed with a special GUID which represents the “My Documents” folder in Windows. The JSFS Agent converts the GUID into an ordinary path before searching for sub-entries.

For simplicity, the example shows a synchronous invocation of “findFiles”. But all service functions can be called asynchronously too.

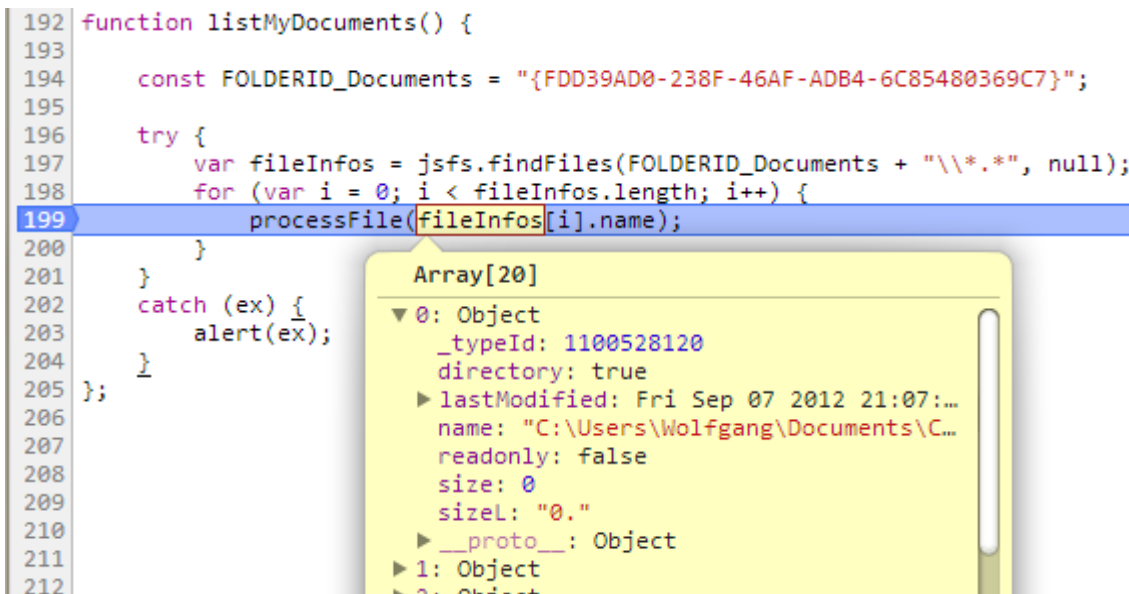


Abbildung 2: Synchronous example for listing files in a folder

## 1.5 Authentication, Connecting Browser to Agent

Referring to Abbildung 1, a resource request from the browser has to be directed to the JSFS Agent running on the same computer in the same user context. This is achieved by using a token during communication between the browser and the JSFS Agent, which is unique for each user.

Both sides acquire the token from “Your Web Application”, see Abbildung 3, “Auth. Request”. In an enterprise network, a single-sign-on mechanism over HTTP, e.g. with Kerberos or NTLM, can help to securely assign such a token.

The JSFS Agent registers its services with the JSFS Dispatcher, see Abbildung 3, “RegisterService (Token)”. If the browser requests a connection to the agent, see Abbildung 3, “getService (Token)”, the JSFS Dispatcher is able to return the right stub.

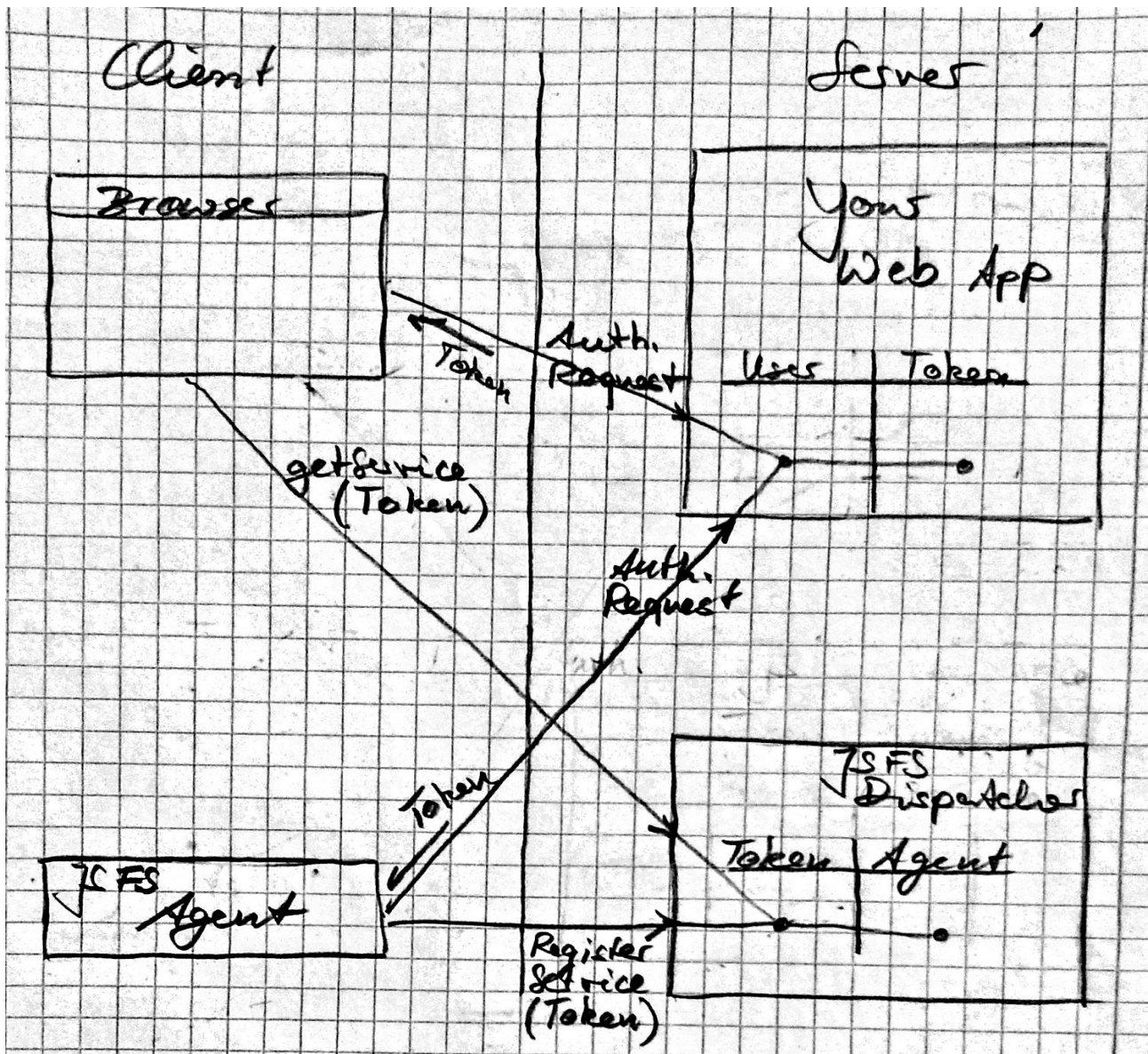


Abbildung 3: Authentication

## 1.6 Security Considerations

### 1.6.1 Same Origin Policy

For security reasons, browsers enforce that requests made by the XMLHttpRequest object can only be sent to the server address that has delivered the JavaScript code.

The easiest way to fulfill this requirement is by running "Your Web Application" and JSFS Dispatcher on the same web server. JSFS Dispatcher is developed in Java EE technology and requires a J2EE Servlet engine. If "Your Web Application" is a J2EE application too, the setup can be very easily – especially if JSFS Dispatcher can be embedded into "Your Web Application".

If "Your Web Application" is a ASP.NET or PHP application etc., or JSFS Dispatcher cannot run on the same web server, a reverse proxy can be inserted between the browser and the web servers. The browser connects only to the proxy and thus believes that there is only one server. Abbildung 4 illustrates this configuration.

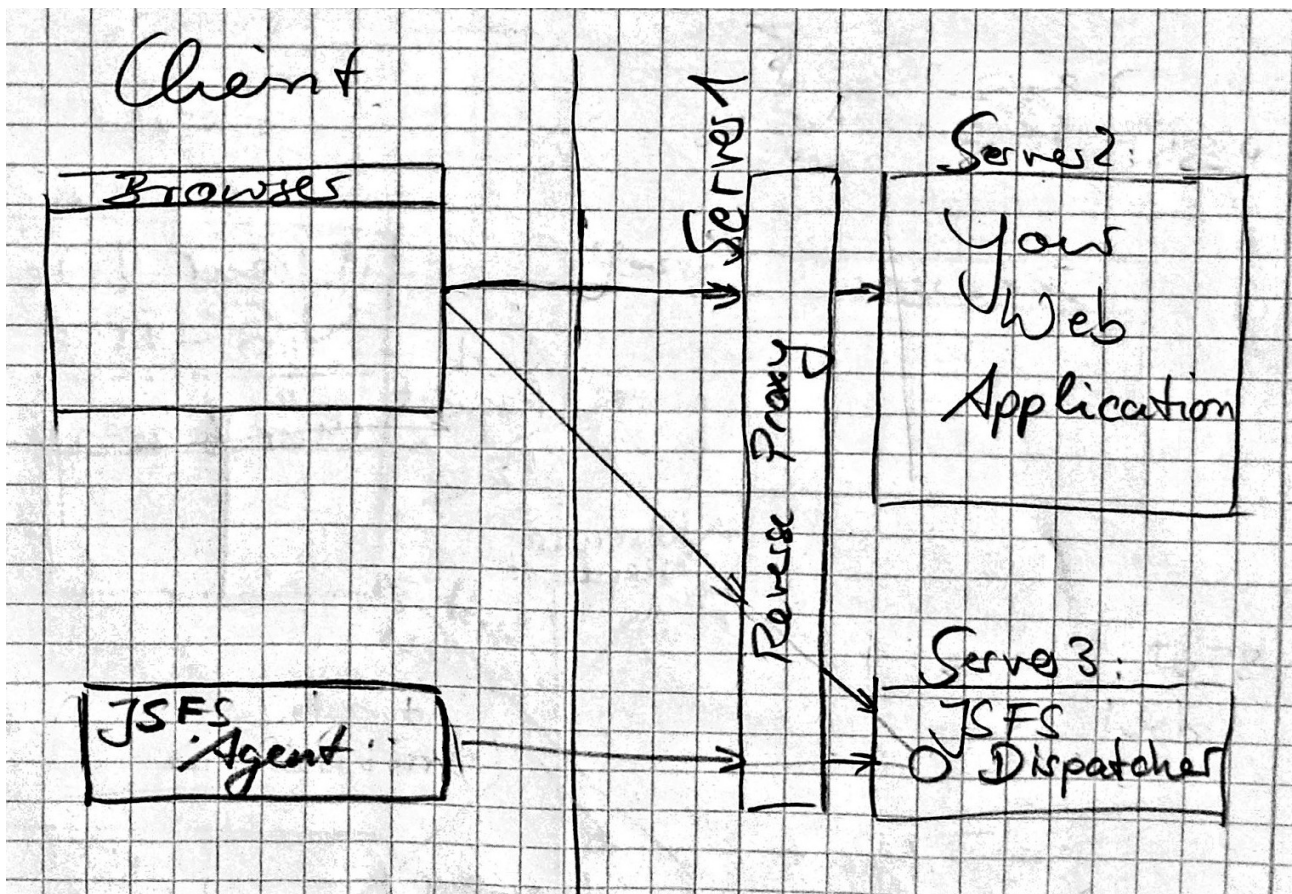


Abbildung 4: Using a reverse proxy

### 1.6.2 Cross Site Scripting Attack

“Your Web Application” must not allow Cross Site Scripting Attacks. Otherwise the attacker can misuse JSFS Agent.

### 1.6.3 Cross Site Request Forgery Attack

JSFS requests are complex JSON objects and use their own 128 bit random session IDs in addition to the application servers session IDs. A Cross Site Request Forgery attack cannot control JSFS Agent.

### 1.6.4 Execution Rights for JSFS Agent

JSFS Agent runs in the security context of the logged in user and does not require special client computer configurations or any extended execution privileges.

Especially, it is not necessary to open a TCP port on the client computer. JSFS Agent connects to JSFS Dispatcher and to “Your Web Application” the same way as the browser does.

### 1.6.5 HTTPS

It is highly recommended that a HTTPS connection is used between the components. This ensures, that the browser and the JSFS Agent are connected to the right servers. Furthermore, the traffic cannot be captured by a Man-in-the-middle attack.



## 1.7 Supported Programming Platforms

The JSFS Dispatcher can only be developed in Java and there are no plans to support other programming platforms. A J2EE Servlet Engine (like Tomcat) is required to run the JSFS Dispatcher.

The JSFS Agent can be written in Java for any platform and in C++ for Windows (Visual Studio 2012). The C#.NET platform could also be used, but currently no starter example is provided. An implementation for QT/C++ might come later.

## 1.8 Communication Layer: BYPS

Serializing and transferring data uses the BYPS communication layer. It provides optimized binary and JSON data transfer over HTTP. A reverse HTTP mechanism (Long-Polling) allows server-to-client and client-to-client communication. This software is currently only available inside JSFS.

BYPS uses a javadoc-based generator for building the serialization code. The interface and data definitions are specified in Java files. Thus, no special interface definition language has to be learned (as far as one has basic Java knowledge).

The generator can create serialization code for Java, JavaScript, C# and C++ (currently only MSVC 2012, C++11 Standard).

## 2 Setup Development Environment

Go through the following steps to setup a development environment in order to compile and debug the JSFS modules.

### 2.1 Java Software Development Kit

Download a recent Java SDK of version 7 or newer.

<http://www.oracle.com/technetwork/java/javase/downloads/index.html>

### 2.2 Download Tomcat 7.0 Application Server

On Windows: download the ZIP file - not the installer package.

<http://tomcat.apache.org/download-70.cgi>

Unpack the ZIP archive into an arbitrary directory.

### 2.3 Download Eclipse IDE for J2EE Development

Eclipse can be downloaded at:

<http://www.eclipse.org/downloads/>

There are several eclipse builds available. Download the “Eclipse IDE for Java EE Development”.

### 2.4 Create Eclipse Workspace

- Start Eclipse
- Choose a workspace directory
- Click Icon “Workbench”





## 2.5 Configure Eclipse for Using Tomcat

- Start Eclipse
- Go to: Window – Preferences – Server – Runtime Environments
- Add...
- Choose: Apache Tomcat 7.0,
- Next >
- Enter the directory where the downloaded Tomcat ZIP archive has been unpacked.
- Finish.

## 2.6 Download JSFS

Download the most recent package of JSFS from:

[www.wilutions.com](http://www.wilutions.com)

Unpack JSFS into the Eclipse workspace directory created in step 2.4.

## 2.7 Import JSFS Projects into Eclipse Workspace

- Start Eclipse
- Go to: File – Import...
- Choose: General – Existing Projects into Workspace
- Choose: Select root directory
- Browse...
- Select workspace directory, OK
- Check all listed projects
- Finish

The Project Explorer should show this projects now:

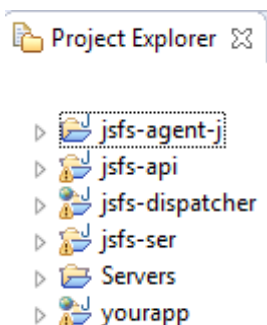


Abbildung 5: Eclipse Project Explorer with JSFS projects

The projects have the following purposes:

jsfs-agent-j	JSFS Agent written in Java.
jsfs-api	Interface definition of the JSFS Agent and JSFS Dispatcher. This interface is evaluated by the BYPS generator. The ANT script byps.xml runs the

	generator which produces all its output into the sub directories of the jsfs-ser project. Except the JavaScript output files, they are written into the files jsfs*.js in the folder yourapp/WebContent.
jsfs-dispatcher	JSFS Dispatcher
jsfs-ser	The BYPS generator creates this classes. They are used to serialize the request and response data in the communication between the browser, the JSFS Agent and the JSFS Dispatcher.
Servers	Definition for running and debugging a Tomcat on port 5080. The tomcat-users.xml defines the role “yourapp-role” and a user “user” with password “pwd” that is used to authenticate to the token service in “Your Web Application”. A logger configuration can be found in the context.xml file.
yourapp	This is a dummy web project that represents the application which uses JSFS. In the diagrams above it is named “Your Web Application”. This project contains the JavaScript code in index.html that invokes the JSFS Agent. Furthermore this application hosts the token generation service in the Servlet class JsfsTokenServlet.

## 2.8 Deploy Web Applications

- Start Eclipse
- Go to: Window – Show View – Other...
- Select: Server – Servers
- OK
- Right-click in Servers view – New – Server
- Select Tomcat v7.0 Server
- Next
- Add All >>
- Finish

Start the server via context menu or toolbar button. Open a browser window and go to address:

<http://localhost:5080/yourapp/>

The “Your Web Application“ should be displayed.

## 2.9 JSFS Agent in C++: Install Microsoft Visual Studio 2012

In order to compile the JSFS Agent for C++, the Microsoft Visual Studio 2012 (or newer) for C++ development has to be installed. The free Express edition is not sufficient since MFC is used. At least the Professional version is required which is available as a free trial version.

The JSFS Agent for C++ can be found in the Eclipse workspace directory in folder “jsfs-agent-cpp”.

### 3 Walk through the Examples

This section discusses the supplied examples. It is assumed that they are run on a Windows. If you are on another operating system, the paths and program names have to be adapted.

The file names, environment variables and program names used in the examples fit to a Windows client computer. It should not be difficult to find appropriate values for other operating systems.

#### 3.1 Start the Applications

- Start the Tomcat server in Eclipse
- Start one of the JSFS Agents, either the C++ or the Java version.  
In order to start the Java version of the JSFS Agent, run the class `com.wilutions.jsfs.Main` in the project `jsfs-agent-j`. The JSFS Agent places an icon in the system tray and shows a message like Abbildung 6.  
This message tells us that the connection to the JSFS Dispatcher has been established and a token has been received from “Your Web Application”. The credentials needed to request a token are currently hard-coded in the Main class. (In production environments, a SSO mechanism could be used where by the credentials are automatically obtained by the operating system and the Java VM).

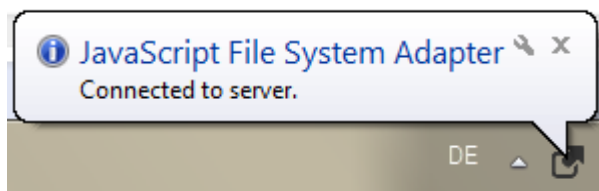


Abbildung 6: Tray icon and message from JSFS Agent

- Open a browser and navigate to address: <http://localhost:5080/yourapp/index.html>. The browser shows a page like this:

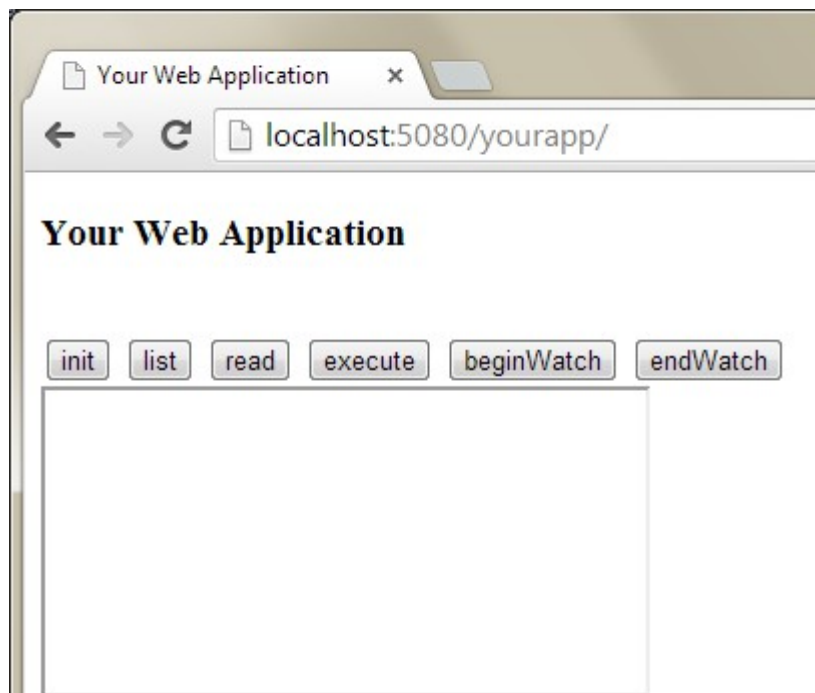


Abbildung 7: Your Web Application

- Start the browsers debugger (key F12 in Chrome and Internet Explorer).

### 3.2 Button “init”: Connect browser to JSFS Dispatcher

- The browser is currently still not connected to the JSFS Dispatcher. Therefore, press button “init”.
- As a result, the user name and password to login to the token service of “Your Web Application” has to be submitted: “user” and “pwd”. If the login is successful, a message box with “OK” is displayed. Press OK.

#### 3.2.1 Button “list”: List files in a folder

- Look for function “fslst” in the debugger window and set a breakpoint at the line “jsfsAgent.listFiles...” as shown in Abbildung 8 for the Chrome browser.

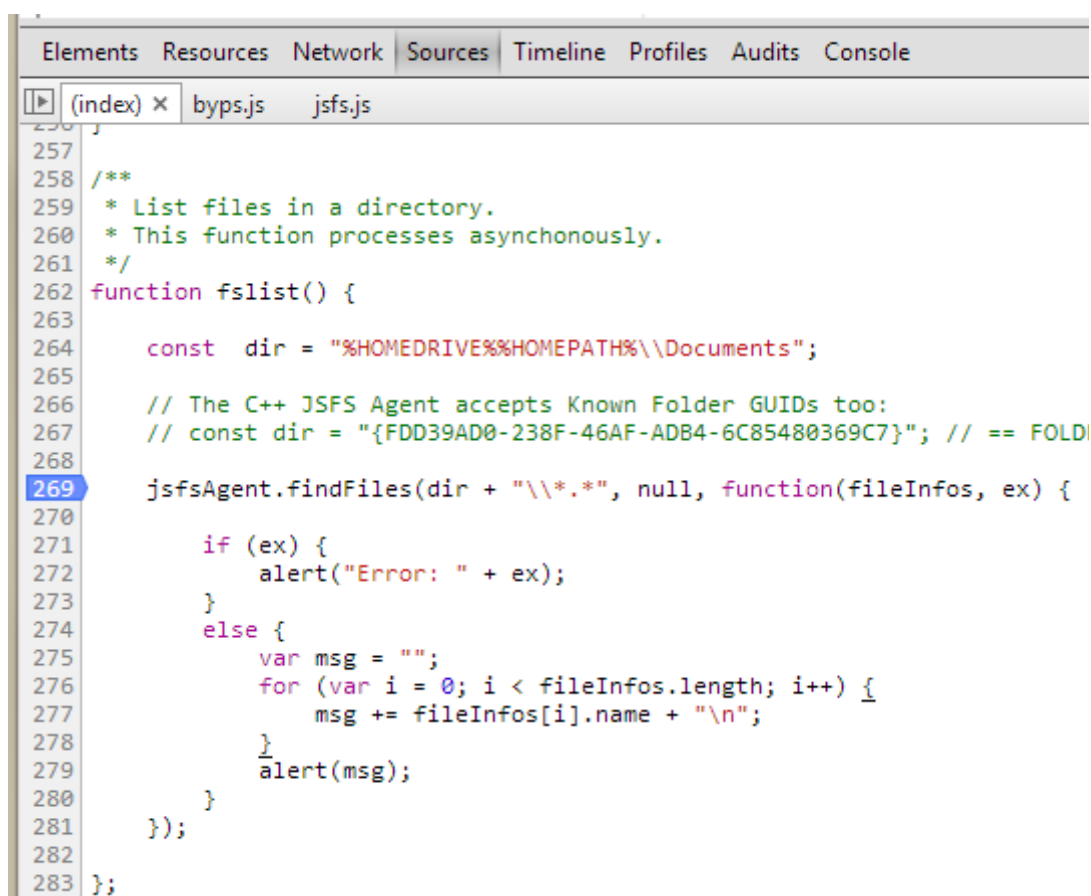


Abbildung 8: Example for listing files

- Click button “list”.
- The function findFiles is executed asynchronously at this line. If the result is available, the function object passed in the last parameter is invoked. Synchronous execution could be achieved by omitting the function parameter. Step with your debugger over this function call.
- In order to step through the code that receives the result, a further breakpoint has to be set, e.g. in line 271 of the screenshot in Abbildung 8. Continue program execution in the debugger.
- The second breakpoint should be hit. Step over the next lines, watch the object contents as you

like and continue program execution.

- An alert box should be displayed listing the files in the folder.

### 3.3 Button “read”: Display file content in an IFRAME

This example shows that a file can be created and modified over the web page. Furthermore it displays the file content in an IFRAME without loading the file on the server.

- Find function “fsreadwrite”. Set a breakpoint on “jsfsAgent.writeAllText”, line 295 in screenshot Abbildung 9.

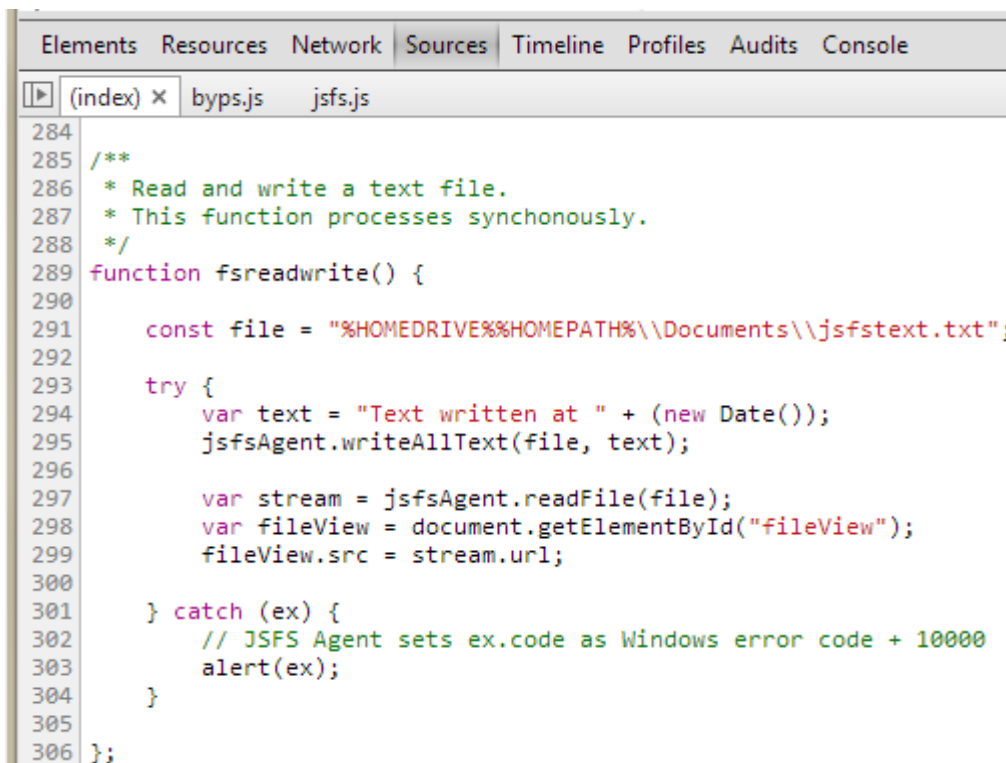


Abbildung 9: Example for writing and reading files

- Click button “read”.
- Since the function “writeAllText” is not supplied with a function object at a last parameter, the function is executed synchronously. Step over this function in the debugger.
- Check in the file system, that the file has been created and written.
- The function “readFile” is executed next. This function reads the contents of the file and is defined with an InputStream object as return value. Since JavaScript does not provide stream objects, a wrapper object for an URL is returned. Step over “readFile”.
- Watch the content of the returned object named “stream”. The member “url” contains an address where the stream content can be downloaded, see Abbildung 10. This URL is only valid for some minutes.

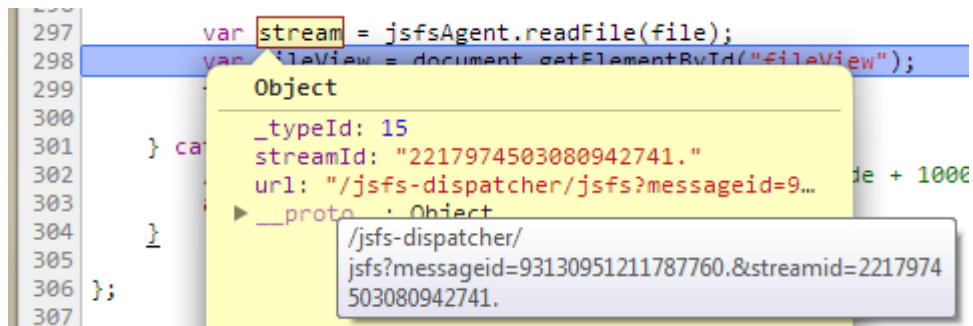


Abbildung 10: JavaScript stream object

- Continue program execution, the file content should be displayed in the IFRAME box under the buttons.

### 3.4 Button “execute”: Start a Program on the Client

This example starts the command line program “sort.exe” which receives lines from standard input and print them alphabetically sorted on standard output. In this case, the result is not returned as a response to the browser request. It is sent to the browser over the “FileSystemNotify” interface. The JSFS Agent invokes the notify function of this interface, when the program has finished and submits the results. Thus, for transferring the result, the communication direction is reversed: the JSFS Agent invokes the browser.

- Look for function “fsexecute” and set a breakpoint in the first line of the function as show in Abbildung 11.

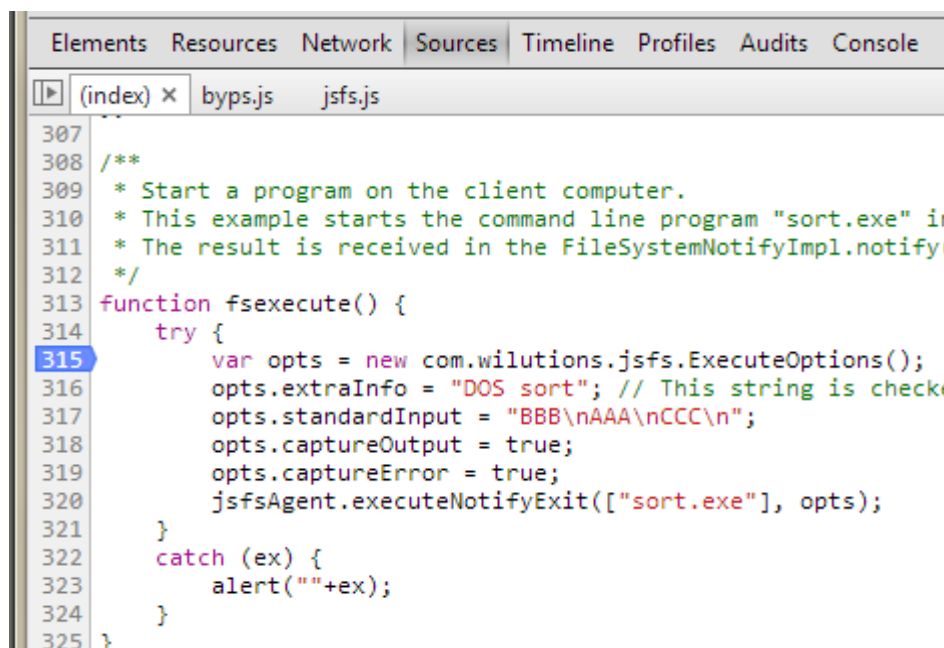


Abbildung 11: Execute a Program

- An object of type “ExeucteOptions” is prepared before the “executeNotifyExit” function is invoked to start the sort application. The member “extraInfo” is set to an identifiert that makes it easier to find out, which kind of execution result in the “FileSystemNotify” implementation is received. Furthermore the input lines are set which have to be passed to the application. In order to receive the results, the standard output pipe has to be captured. Therefore, the member “captureOutput” is set. Before continuing the debugger, set a

breakpoint where the result is received. This is in function “notify” of the object “FileSystemNotifyImpl”, see Abbildung 12.

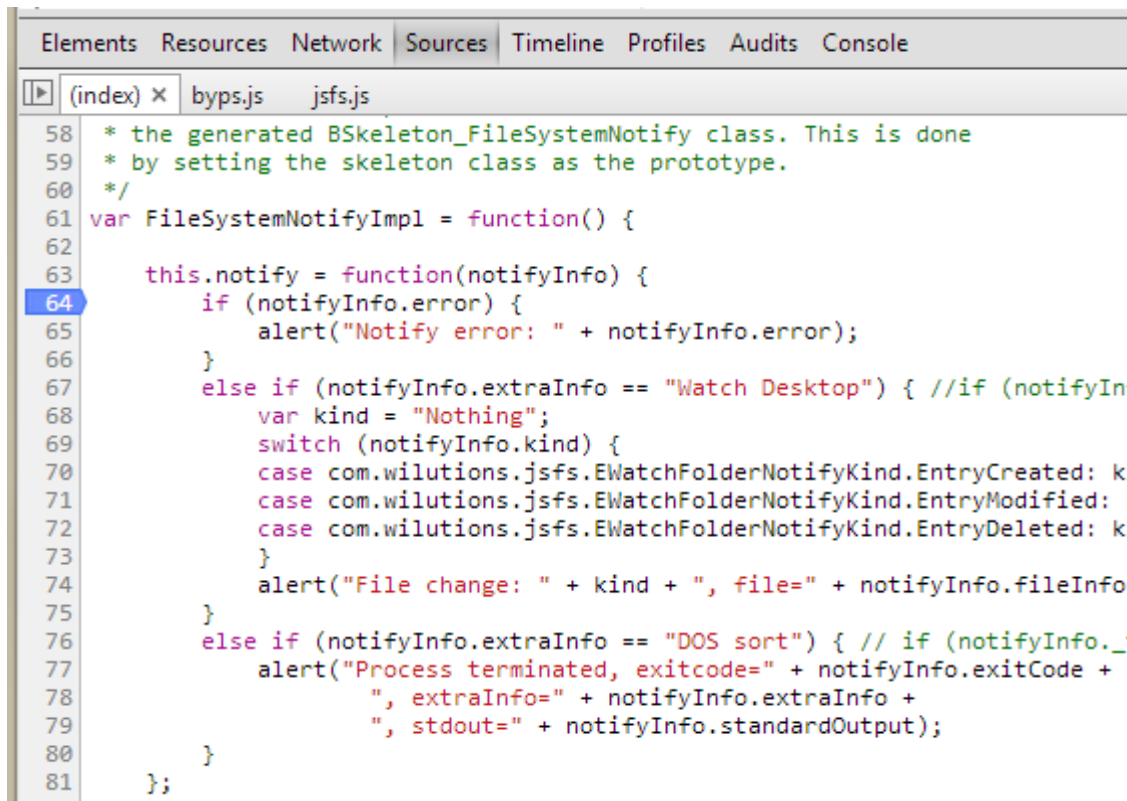


Abbildung 12: Notify interface implementation

- Continue debugger execution. The breakpoint in “notify” should be hit.
- Step through the function and watch the passed “notifyInfo” object. After continuing the execution an alert box shows the sorted lines.

### 3.5 Button “beginWatch”: Watch a Folder

This example watches a folder in the file system and shows an alert box, if a file is created, deleted or modified. The notifications about changes are transmitted over the “FileSystemNotify” service.

- Find function “beginWatch” in the source code and set a breakpoint at the call to “jsfsAgent.beginWatchFolder”.



```

340  call function endWatch().
341  */
342  var watchFolderId = 0;
343  function beginWatch() {
344
345      var dir = "%HOMEDRIVE%%HOMEPATH%\\Desktop";
346
347      watchFolderId = jsfsAgent.beginWatchFolder(dir,
348          false,                // Do not watch sub folders
349          "Watch Desktop"      // This helps FileSystemNotif
350      );
351
352      alert("The browser displays a message box, when you create
353  }

```

Abbildung 13: Begin watching a folder

- Click on button “beginWatch”. The debugger execution stops at the breakpoint.
- The first parameter of the function “beginWatchFolder” specifies the directory to be watched. In this example, the desktop folder is supplied. The next parameter tells the function whether sub-directories should be watched too. The third parameter is an identifier that helps to find the right handler code in the “FileSystemNotifyImpl.notify”. The return value is a handle to internal to the watcher object in the JSFS Agent. It has to be released with “FileSystemService.endWatchFolder”.
- Continue program execution. An alert box shows a message which tells that the folder is being watched now. Click OK.
- Set a breakpoint in the function “FileSystemNotifyImpl.notify” as shown in Abbildung 12.
- Create a new file on the desktop. The breakpoint should be hit.
- Step through the function and watch the passed “notifyInfo” object. After continuing the execution an alert box shows the modification.
- If a file is renamed, three notifications are received: “EntryDeleted”, “EntryCreated”, “EntryModified”.
- Stop watching the folder with a click on “endWatch”.

### 3.6 Authentication

The authentication procedure is defined by the BYPS communication framework. It expects an implementation of the BAuthentication interface which has the following functions:

authenticate	<p>Performs authentication with the server.</p> <p>For the JSFS application, it requests a token from “Your Web Application” by sending a HTTP GET request to the token service (see helper function “_internalAuthenticate”). On success, it registers a “FileSystemNotifyImpl” object with the JSFS Dispatcher and queries for the service interface of the JSFS Agent. The JSFS Agent interface is stored in the global variable “jsfsAgent”.</p>
isReloginException	<p>Checks whether the given exception indicates that a new authentication should be processed.</p>

	<p>Any exception that occurs during a request to the services of the “BClient” object is routed through this function. If the function returns true, the framework re-authenticates and performs the request again.</p> <p>Since the JSFS application does not define special exceptions that denote an invalid session, the function forwards the exception to a default function in the framework.</p> <p>The exceptions that may occur in the functions of the “jsfsAgent” object are not routed through the “isReloginException” since the “jsfsAgent” is not a service of the “BClient” object.</p>
getSession	Returns an object that represents the current session and that is sent with every request. This functionality is not used for the JSFS application.

The functions “authenticate” and “getSession” can be implemented synchronously or asynchronously. It depends on how the “start” function of the “BClient” object is called. If “start” is called with a function object that is used as a callback for the result, the “authenticate” and “getSession” functions must be implemented asynchronously. This is the case in the present example.

- Set a breakpoints in the “authenticate” and “\_internalAuthenticate” functions.
- Click “init” and step through the program.

## 4 Customize JSFS Agent

The service interfaces of the JSFS Agent and the JSFS Dispatcher can be seen as entities of an API from the perspective of the JavaScript code in the browser. For this reason, in the terms of BYPS the interfaces and classes used in communication are called an API.

The language to be used to define an API is Java. Hence, no special interface definition language has to be learned.

Based on the API definition, the BYPS generator creates code for serializing classes and for providing a remote-procedure-call mechanism. This code is written into the project “jsfs-ser”. The generator is started by Ant script byps.xml in project “jsfs-api” (see <http://ant.apache.org/> for more information about Ant).

### 4.1 JSFS API

It is a good practice to collect all the API entities in a single project, here it is the the project “jsfs-api”. The entire API must have one descriptor class named BApi with at least a name and a **version number**. In this case, the API descriptor is the class com.wilutions.jsfs.BApi.

In general, API classes can only consist of data members and cannot have functionality – except trivial getter and setter functions. All the functionality must be placed in service interfaces.

**In order to create backward compatible APIs, the version number must be incremented when new symbols are added.** The new symbols must be tagged with the javadoc comment “@since” followed by the version number since when they are available. Other modifications, like removing symbols, changing the type of data members or changing the parameter list of functions, break compatibility and should be avoided.

## 4.2 Example: Add a Data Member to FileInfo

This example shows the steps to add a data member, e.g. to the FileInfo class. Adding a function to an interface can be done the same way.

- Start Eclipse

### Increment the API version number:

- Open the class com.wilutions.jsfs.BApi in the code editor.
- Set version number e.g. “1.0.0.1”.

### Add class member:

- Open class com.wilutions.jsfs.FileInfo from the project “jsfs-api” in the code editor. Add a new “protected” member of type “boolean” named “hidden”.

```
/**
 * True for hidden file or directory.
 * @since 1.0.0.1
 */
protected boolean hidden;
```

- Generate a getter and setter function via the context menu – Source – Generate Getters and Setters...
- Save the files

### Run the BYPS generator:

- Right-click on byps.xml – Run As – Ant Build.
- The console windows in Eclipse should show the generation process.
- When finished, **refresh the project “jsfs-ser”** by Right-click – Refresh.

### Extend the JSFS Agent:

- Open file “FileInfoHelper.java” in project “jsfs-agent-j”.
- In function “makeFileInfo” add line “fi.setHidden(file.isHidden());”
- Save “FileInfoHelper.java”

### Extend the C++ Agent:

- Open “jsfs-agent-cpp” in Visual Studio.
- (Open file “jsfs-ser/src-api/JSFS-api.h” to check whether FileInfo class has been extended)
- Open file “FileSystemServiceImpl.cpp” and go to function “fileInfoFromWin32FindData”.
- Add line “fi->setHidden((fd.dwFileAttributes & FILE\_ATTRIBUTE\_HIDDEN) != 0);”.
- Compile project.

### **Test your modification:**

- E.g. store a hidden file in the directory used in “fslist” and click the “list” button. Check in the debugger window that the new member is properly set.

## **4.3 Add a New Service Interface**

In order to add a new service interface, a new Java interface has to be defined in the “jsfs-api” project. The interface can be created in an arbitrary package but not in the default package. It has to extend “byps.BRemote”. The interface functions must be declared to throw a byps.RemoteException.

If the interface should be implemented on the client side, which is here the JSFS Agent or the JavaScript side, it must be tagged with “@BClientRemote”, see “FileSystemNotify” or “FileSystemService”.

If only the server side, here JSFS Dispatcher, will provide an implementation, no special tag is required.

New interfaces must also be tagged with a @since value.

## **4.4 Add a New Value Class**

As already mentioned, classes are used to transmit data and cannot have functionality (all the functionality is placed in interfaces). This is why classes are called “Value Classes” in the terms of BYPS.

Value Classes have to implement the marker interface “java.io.Serializable” and have to define the unique (generated) “serialVersionUID” member. The lower 4 bytes of this value are taken to compute the internally used type ID. This type ID must also be unique in the domain of an API, otherwise the generator will stop with an error message. If you miss to define a “serialVersionUID”, the generator creates one set to a 4bit wide random number.

New classes must be tagged with the @since tag as all other new symbols.

## **4.5 Generator Can Check for Incompatible Modifications**

The BYPS generator creates an XML file containing the entire API definitions: bapi\_new.xml. This file can be used by the generator in the next run in order to detect, whether the modified API is compatible to the previous one. Therefore, the file must be renamed to “bapi.xml”, before the generator is started the next time.

You may want to rename file “bapi\_new.xml” to “bapi.xml” every time when you check in the code into the source code control system.

## **4.6 Remove Obsolete Functions Before Release**

The original source code of the JSFS Agent is written as an example for general purpose file system access.

*In order to constrain the potential damage an attacker could cause in case of a successful attack, it is highly recommended to remove all obsolete example functions and expose only functions that are actually required.*

## **5 Related Work: Gibraltar**

A similar project for accessing hardware resources from JavaScript was published by Microsoft

Research in 2012, see [MSGIB]. The authors suggest to run a HTTP server, the “device server”, as an extension component on the “Client”.

An advantage of Gibraltar over JSFS is that the data is directly exchanged between the browser and the extension component, and is not routed over the network.

But Gibraltar has some disadvantages compared to JSFS:

- Complex installation procedure of the device server:
  - Installation requires firewall configuration in order to allow the device server listening on a TCP port and allowing requests from localhost but disallowing requests from other addresses.
  - Installation on Terminal Servers require “Virtual IP Addressing” to allow multiple HTTP servers listen on the same TCP port.
- The device server is visible to all web pages. If it is targeted by an attacker, the user might be overextended to make the right decisions. In contrast, JSFS Agent is not visible to any web page and JSFS Dispatcher runs on a server that is watched by an administrator.
- Authentication with the device server requires to workaround the same-origin-policy. This actually might not cause a security leak. But it might be a challenge to explain the customer that the program needs to bypass a browser security mechanism.
- The device server is a general purpose component which makes it extremely interesting for a large range of attackers. In contrast, JSFS Agent can be constrained to the special requirements of the web application which is probably only useful for a smaller number of attackers.

*As a security advantage (see 1.3), the authors claim that 7613 lines of Java code is more secure than million-plus lines of C++ code in modern browsers. But the Java code runs on a JVM which has also a million lines of C/C++ code (Counted number of lines in [OPENJDK] in \*.c\* and \*.h\* files). Besides that, Java code might not crash as often as native code does, but it can also have serious bugs – and indeed it has, as we learned from the news in the past.*

## 6 Bibliography

### References

MSGIB: Kaisen Lin, David Chu, James Mickens, Li Zhuang, Feng Zhao, and Jian Qiu, Gibraltar: Exposing Hardware Devices to Web Pages Using AJAX, 2012,  
<http://research.microsoft.com/apps/pubs/default.aspx?id=161386>

OPENJDK: , , , <http://openjdk.java.net/>