

The CanFestival CANopen stack manual.

CanFestival v3.0 Manual

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1 - Introduction

CanFestival is an OpenSource (LGPL and GPL) CANopen framework.

1.1) The CanFestival project

This project, initiated by Edouard TISSERANT in 2001, has grown thanks to Francis DUPIN and other contributors.

Today, CanFestival focuses on providing an ANSI-C platform independent CANopen stack that can be implemented as master or slave nodes on PCs, Real-time IPCs, and Microcontrollers.

CanFestival is a project supported by Lolitech.

1.2) What is CANopen

CANopen is a CAN based high level protocol. It defines some protocols to :

1. Configure a CAN network.
2. Transmit data to a specific node or in broadcast.
3. Administrate the network. For example detecting a not responding node.

The documentation can be found on the CAN in Automation website :

<http://www.can-cia.de/canopen>

The most important document about CANopen is the normative CiA Draft Standard 301, version 4.02. You can now download the specification from the CAN in Automation website at no cost.

To continue reading this document, let us assume that you have read some papers introducing CANopen .

2 - CanFestival Features

2.1) Tools

The CANopen library is coming with some tools :

1. Object Dictionary editor GUI. WxPython Model-View-Controller based GUI, that helps a lot in generating object dictionary source code for each node.

2. A configure script, that let you chose compile time options such as target CPU/HOST, CAN and TIMER drivers.

This script has not been generated with autoconf, it has been made keeping micro-controller target in mind.

2.2) Multi-Platform

1. Library source code is C-ANSI.
2. Driver and examples coding conventions merely depend on target specific contributor/compiler.
3. Unix compatible interfaces and examples should compile and run on any Unix system (tested on GNU/Linux and GNU/FreeBSD).

2.3) CANopen standard conformance

2.3.1) DS-301

Supported features should conform to DS301. V.4.02 13 february 2002.

1. NMT master and slave
2. Heartbeat consumer and producer
3. NodeGuard slave reponder and basic master without tracking
4. SYNC service
5. SDO multiples client and server, segmented and expedited
6. PDO : TPDO and RPDO, with respect to transmission type
7. PDO mapping from/to OD variables bit per bit.
8. EMCY : Send and receive and keeps track of emergency objects
9. Data types : 8 to 64 bits values, fixed length strings.

2.3.2) DS-302

Only concise DFC is supported.

2.3.3) DS-305

LSS services are fully supported although they have to be enabled at compile time. Additionally, FastScan LSS service is also optionally enabled.

3 - How to start

3.1) Host requirements

What you need on your development workstation.

3.1.1) Object Dictionary Editor GUI

1. Python, with
2. wxPython modules installed (at least version 2.6.3).
3. Gnosis xml tools. (Optional can also be installed locally to the project automatically with the help of a Makefile. Please see “Using Dictionary Editor GUI”)

3.1.2) Linux and Unix-likes

1. Linux, FreeBSD, Cygwin or any Unix environment with GNU toolchain.
2. The GNU C compiler (gcc) or any other ANSI-C compiler for your target platform.
3. Xpdf, and the official 301_v04000201.pdf file in order to get GUI context sensitive help.
4. GNU Make
5. Bash and sed

3.1.3) Windows (for native win32 target)

1. Visual Studio Express 2005 or worst.
2. Microsoft platform SDK (requires Genuine Advantage)
3. Cygwin (for configuration only)
4. MinGW/MSYS

3.2) How to get CanFestival

Please always use CVS, this is the best way to get the most reactive support from the developer community :

```
cvs -d:pserver:anonymous@lolitech.dyndns.org:/canfestival login
```

(type return, without entering a password)

Then, enter :

```
cvs -z3 -d:pserver:anonymous@lolitech.dyndns.org:/canfestival co -P CanFestival
```

4 - Understanding Canfestival

4.1) CanFestival Project tree layout

Simplified directory structure.

```
./src ANSI-C source of \canopen stack
./include Exportables Header files
./drivers Interfaces to specific platforms/HW
./drivers/unix Linux and Cygwin OS interface
./drivers/win32 Native Win32 OS interface
./drivers/timers_xeno Xenomai timers/threads (Linux only)
./drivers/timers_rtai Rtai timers/threads (Linux only)
./drivers/timers_kernel Linux kernel timer/threads
./drivers/timers_unix Posix timers/threads (Linux, Cygwin)
./drivers/can_virtual_kernel Fake CAN network (kernel space)
./drivers/can_serial Serial point to point and PTY hub (*nix only)
./drivers/can_peak_linux PeakSystem CAN library interface
./drivers/can_peak_win32 PeakSystem PCAN-Light interface
./drivers/can_uvccm_win32 Acacetus's RS232 CAN-uVCCM interface
./drivers/can_virtual Fake CAN network (Linux, Cygwin)
./drivers/can_vcom VScom VSCAN interface
./drivers/hcs12 HCS12 full target interface
./examples Examples
./examples/TestMasterSlave 2 nodes, NMT SYNC SDO PDO, win32+unix
./examples/TestMasterSlaveLSS 3 nodes, NMT SYNC SDO PDO LSS, win32+unix
./examples/TestMasterMicroMod 1 node, control Peak I/O Module, unix
./examples/gene_SYNC_HCS12 Just send periodic SYNC on HCS12
./examples/win32test Ask some DS301 infos to a node (win32)
./objdictgen Object Dictionary editor GUI
```



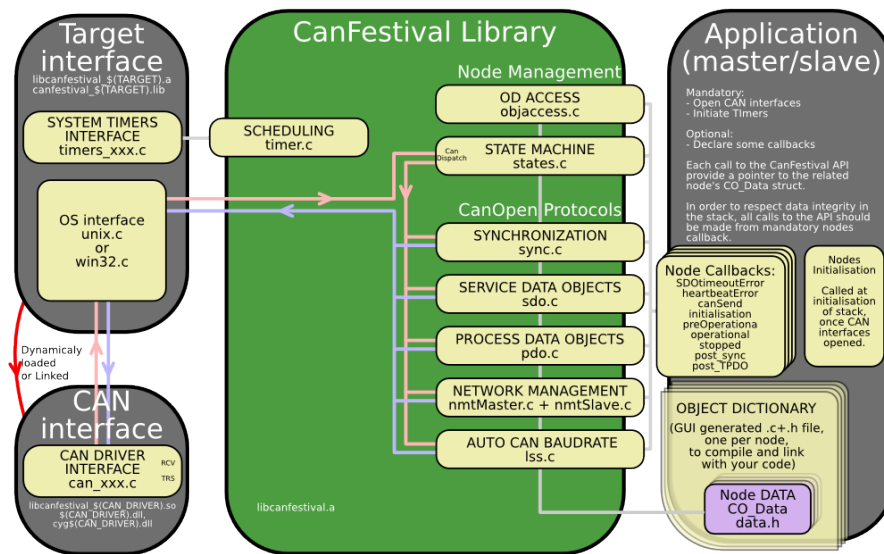
```

./objdictgen/config Pre-defined OD profiles
./objdictgen/examples Some examples/test OD
./doc Documentation source

```

4.2) Implement CanFestival in your application

Implementation overview

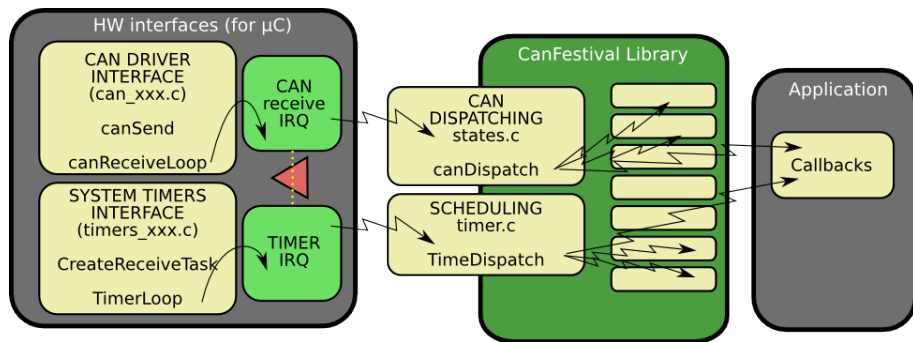


4.3) CanFestival CAN interfaces

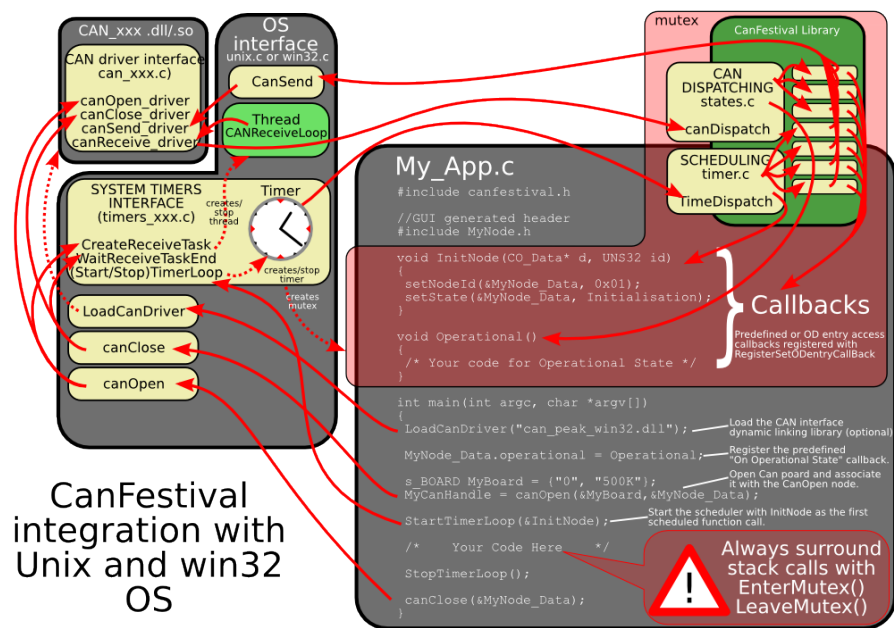
Because most CAN controllers and drivers implement FIFOs, CanFestival consider sending message as a non blocking operation.

In order to prevent reentrant calls to the stack, messages reception is implemented differently on μ C and OS.:

1. μ C must provide interruption masking, mutually excluding timer and CAN receive interrupts.



- OS must provide a receive thread, a timer thread and a mutex. CAN reception should be a blocking operation.



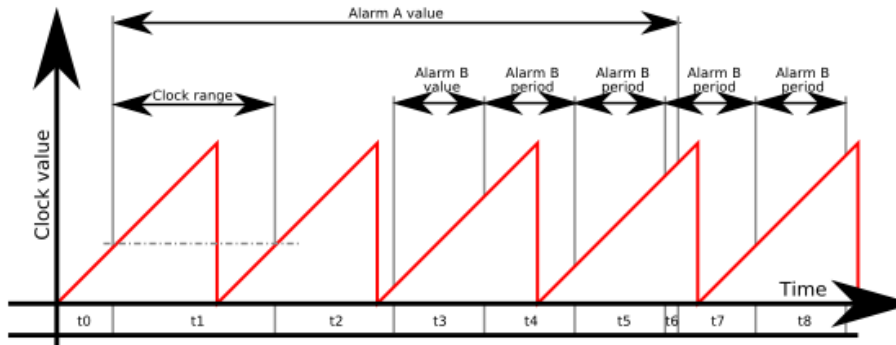
4.4) CanFestival event scheduling

A CANopen node must be able to take delayed actions.

For instance, periodic sync emission, heartbeat production or SDO time-out need to set some alarms that will be called later and do the job.

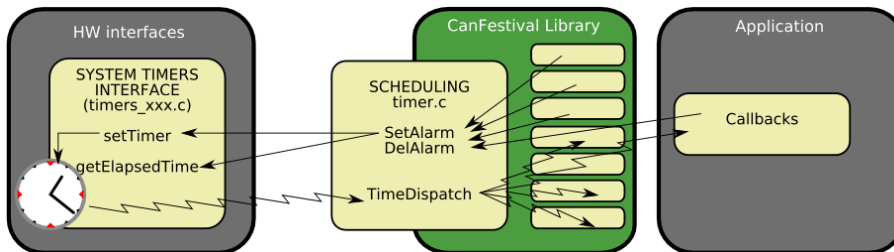
µC generally do not have enough free timers to handle all the CANopen needs directly. Moreover, CanFestival internal data may be corrupt by reentrant calls.

CanFestival implement a micro -scheduler (timer.c). It uses only one timer to mimic many timers. It manage an alarm table, and call alarms at desired time.



Scheduler can handle short clock value ranges limitation found on some μC . As an example, value range for a 16bit clock counter with $4\mu\text{s}$ tick is crossed within 0.26 seconds... Long alarms must be segmented.

Chronogram illustrate a long alarm (A) and a short periodic alarm (B), with a $A \text{ value} > \text{clock range} > B \text{ value}$. Values $t_0 \dots t_8$ are successive `setTimer` call parameter values. t_1 illustrates an intermediate call to `TimeDispatch`, caused by a delay longer than clock range. Because of long alarm segmentation, at the end of t_1 , `TimeDispatch` call will not trig any alarm callback.



5 - Linux Target

Linux target is default configure target.

5.1) Linux Compilation and installation

Call `./configure - help` to see all available compile time options.

After invoking `./configure` with your platform specific switches, just type `make`.

```
./configure [options]
make
make install
```

5.1.1) Standard Linux node

```
./configure --timers=unix
```

To do a CANopen node running on PC -Linux, you need :

1. A working linux distribution
2. One or more Peak system PC CAN interface and the last Peak Linux driver installed.

5.1.2) Real -Time Linux node

With Xenomai :

```
./configure --timers=xeno
```

With Rtai :

```
./configure --timers=rtai
```

To do a CANopen node running on PC -Linux, you need :

1. A working Linux distribution patched with XENOMAI (2.1 or greater) or RTAI (3.6).
2. One or more Peak system PC CAN interface and the last Peak Real Time Linux driver installed.

5.1.3) Linux kernel node

To do a CANopen node running on PC-Linux in kernel space, you need:

1. A working Linux distribution with pre-built 2.6.x.x kernel sources
2. A CAN card driver compatible with CanFestival

5.1.4) CAN devices

Currently supported CAN devices and corresponding configure switch:

a) Peak systems

```
./configure --can=peak_linux
```

PeakSystems CAN interface is automatically chosen as default CAN interface if libpcan is present in the system.

Please download driver at <http://www.peak-system.com/linux> and follow instructions in order to install driver on your system.

b) Socket-Can (<http://socketcan.berlios.de>)

```
./configure --can=socket
```

c) Serial

```
./configure --can=serial
```

The CAN serial driver implements a 1:1 serial connection between 2 CAN devices. For example, you can connect 2 CANFestival applications via a NULL modem cable.

Also with this driver comes a software hub, for up to 16 CANFestival apps to be connected on a single PC, with an optional connection to another CAN driver. Note that only the serial driver is supported at this time. The hub uses ptys (pseudo ttys) available on a *nix like system.

d) LinCan

```
./configure --can=lincan
```

e) Virtual CAN interfaces (for test/debug)

```
./configure --can=virtual
```

or, for kernel space:

```
./configure --can=kernel_virtual
```

Virtual CAN interface use Unix pipes to emulate a virtual CAN network. Each message issued from a node is repeat to all other nodes. Currently only works with nodes running in the same process, and does not support work with Xenomai or RTAI.

f) VScom

```
./configure --can=vscom
```

The VSCAN API archive will be automatically downloaded and decompressed (unzip required). See www.vsc.com.de for available adapters.

5.1.5) LSS services

Canfestival optionally supports LSS services but they must be enabled.

```
./configure --enable-lss
```

Additionally, the FastScan LSS service can also be enabled.

```
./configure --enable-lss --enable-lss-fs
```

5.2) Testing your CanFestival installation

5.2.1) User space

Sample provided in `/example/TestMasterSlave` is installed into your system during installation.

`TestMasterSlave`

Default CAN driver library is `libcanfestival_can_virtual.so.`, which will simply pass CAN messages through Unix pipes between Master and Slave.

You may also want to specify different can interface and define some CAN ports. Another example using Peak's dual PCMCIA (configure and install with `-can=peak`) :

```
TestMasterSlave -l libcanfestival_can_peak.so -s 40 -m 41
```

If the LSS services are enabled the sample provided in `/example/TestMasterSlaveLSS` will be also installed. It behaves the same as `TestMasterSlave` except that there are 2 slave nodes without a valid nodeID so the the initializations is done via the LSS services. If FastScan optional service is enabled the example will use it.

5.2.2) Kernel space

`example/kerneltest`

It's based on `TestMasterSlave` example and has the same functionality. Uses virtual can driver as default too. After successful installation you can insert the module by typing: `modprobe canf_ktest` Module control is done by simple console '`canf_ktest_console`' which is used to start/stop sending data.

6 - Windows Targets

CanFestival can be compiled and run on Windows platform. It is possible to use both Cygwin and win32 native runtime environment.

6.1) Object Dictionary Editor GUI installation.

Please refer to [8.2.1\)Using Dictionary Editor GUI](#)

6.2) CYGWIN

6.2.1) Requirements

Cygwin have to be installed with those packages :

1. gcc
2. unzip
3. wget
4. make

Currently, the only supported CAN devices are PeakSystems ones, with PcanLight driver and library.

Please download driver at http://www.peak-system.com/themen/download_gb.html and follow instructions in order to install driver on your system.

Install Cygwin as required, and the driver for your Peak CAN device.

Open a Cygwin terminal, and follow those instructions:

6.2.2) Cygwin configuration and compilation

a) A single node with PcanLight and Peak CAN -USB adapter

Download the PCAN-Light Zip file for your HW (URL from download page):

```
wget http://www.peak-system.com/files/usb.zip
```

Extract its content into your cygwin home (it will create a “Disk” directory):

```
unzip usb.zip
```

Configure CanFestival3 providing path to the desired PcanLight implementation:

```
cd CanFestival -3
export PCAN_INCLUDE=~/.Disk/PCAN-Light/Api/
export PCAN_HEADER=Pcan_usb.h
export PCAN_LIB=~/.Disk/PCAN-Light/Lib/Visual\ C++/Pcan_usb.lib
./configure --can=peak_win32
make
```

In order to test, you have to use another CanFestival node, connect with a CAN cable.

```
cp ~/.Disk/PCAN-Light/Pcan_usb.dll .
./examples/TestMasterSlave/TestMasterSlave \
-l drivers/can\_peak\_win32/cygcan\_peak\_win32.dll \
-S 500K -M none
```

Then, on the other node :

```
./TestMasterSlave -l my_driver.so -S none -M 500K
```

Now messages are being exchanged between master and slave node.

b) Two nodes with PcanLight and Peak dual PCMCIA -CAN adapter Download the PCAN-Light Zip file for your HW (URL from download page):

```
wget http://www.peak-system.com/files/pccard.zip
```

Extract its content into your cygwin home (it will create a “Disk” directory):

```
unzip pccard.zip
```

The configure CanFestival3 providing path to the desired PcanLight implementation:

```
export PCAN_INCLUDE=~/.Disk/PCAN-Light/Api/
export PCAN_HEADER=Pcan_pcc.h
export PCAN_LIB=~/.Disk/PCAN-Light/Lib/Visual\ C++/Pcan_pcc.lib
export PCAN2_HEADER=Pcan_2pcc.h
export PCAN2_LIB=~/.Disk/PCAN-Light/Lib/Visual\ C++/Pcan_2pcc.lib
```


In order to test, just connect together both CAN ports of the PCMCIA card. Don't forget 120ohms terminator.

```
cp ~/Disk/PCAN-Light/Pcan_pcc.dll .
cp ~/Disk/PCAN-Light/Pcan_2pcc.dll .
./examples/TestMasterSlave/TestMasterSlave \
-l drivers/can_peak_win32/cygcan_peak_win32.dll
```

Messages are then exchanged between master and slave node, both inside TestMasterSlave's process.

6.3) Visual Studio C++

6.3.1) Requirements

Minimal Cygwin installation is required at configuration time in order to create specific header files (config.h and cancfg.h). Once this files created, cygwin is not necessary any more.

Project and solution files have been created and tested with Visual Studio Express 2005. Be sure to have installed Microsoft Platform SDK, as recommended at the end of Visual Studio installation.

6.3.2) Configuration with cygwin

Follow instructions given at [Cygwin configuration and compilation](#), but do neither call make nor do tests, just do configuration steps. This will create headers files accordingly to your configuration parameters, and the desired CAN hardware.

6.3.3) Compilation with Visual Studio

You can either load independent “*.vcproj” project files along your own projects in your own solution or load the provided “CanFestival -3.vc8.sln” solution files directly.

Build CanFestival -3 project first.

a) **PcanLight and the can_peak_win32 project.** Chosen Pcan_xxx.lib and eventually Pcan_2xxx.lib files must be added to can_peak_win32 project before build of the DLL.

6.3.4) Testing

Copy eventually needed dlls (ie : Pcan_Nxxx.lib) into Release or Debug directory, and run the test program:

```
TestMasterSlave.exe -l can_peak_win32.dll
```

6.4) MSYS

6.4.1) Requirements

Download from : http://sourceforge.net/project/showfiles.php?group_id=2435

1. MSYS-1.0.10.exe
2. MinGW-5.1.3.exe
3. mingwPORT (which contains wget-1.9.1)

Please download driver at http://www.peak-system.com/themen/download_gb.html and follow instructions in order to install driver on your system. Install MSYS and MingW as required, and the driver for your Peak CAN device. Open a MSYS terminal, and follow those instructions:

- extract wget-1.9.1-mingwPORT.tar.bz2
- copy wget.exe in c:\msys\1.0\bin\
- start MSYS and check the file /etc/fstab contain the line c:/MinGW/mingw

6.4.2) MSYS configuration and compilation

Instructions for compilation are nearly the same as CYGWIN part.

a) A single node with PcanLight and Peak CAN-USB adapter
Download the PCAN-Light Zip file for your HW (URL from download page):

```
wget http://www.peak-system.com/files/usb.zip
```

Extract its content into your MSYS's home (it will create a " Disk" directory):

```
unzip usb.zip
```

Configure CanFestival3 providing path to the desired PcanLight implementation:

```
cd CanFestival-3
export PCAN_INCLUDE=~/.Disk/PCAN-Light/Api/
export PCAN_HEADER=Pcan_usb.h
export PCAN_LIB=~/.Disk/PCAN-Light/Lib/Visual\ C++/Pcan_usb.lib
./configure --can=peak_win32
make
```

In order to test, you have to use another CanFestival node, connect with a CAN cable.

```
cp ~/.Disk/PCAN-Light/Pcan_usb.dll .
./examples/TestMasterSlave/TestMasterSlave \
  -l drivers/can_peak_win32/cygcant_peak_win32.dll \
  -S 500K -M none
```

Then, on the other node :

```
./TestMasterSlave -l my_driver.so -S none -M 500K -m 0
```

Now messages are being exchanged between master and slave node.

b) Two nodes with PcanLight and Peak dual PCMCIA-CAN adapter

Download the PCAN-Light Zip file for your HW (URL from download page):

```
wget http://www.peak-system.com/files/pccard.zip
```

Extract its content into your MSYS's home (it will create a " Disk" directory):

```
unzip pccard.zip
```

The configure CanFestival3 providing path to the desired PcanLight implementation:

```
export PCAN_INCLUDE=~/.Disk/PCAN-Light/Api/
export PCAN_HEADER=Pcan_pcc.h}
export PCAN_LIB=~/.Disk/PCAN-Light/Lib/Visual\ C++/Pcan_pcc.lib
export PCAN2_HEADER=Pcan_2pcc.h
export PCAN2_LIB=~/.Disk/PCAN-Light/Lib/Visual\ C++/Pcan_2pcc.lib
```

In order to test, just connect together both CAN ports of the PCMCIA card. Don't forget 120ohms terminator.

```
cp~/Disk/PCAN-Light/Pcan_pcc.dll ~.
cp ~/Disk/PCAN-Light/Pcan_2pcc.dll ~.
./examples/TestMasterSlave/TestMasterSlave \
-l drivers/can\_peak\_win32/cygcan\_peak\_win32.dll -m 0 -s 1
```

Messages are then exchanged between master and slave node, both inside TestMasterSlave's process.

7 - Motorola HCS12

The examples have been tested on a MC9S12DG255 mounted on a Elektron-ikladen HCS12 T -board.

Beware that there are few differences in the MSCAN module of the 68HC12 and HCS12 microcontroller. For a HC12, you must adapt the driver that we provide for the HCS12.

For the difference MSCAN HC12/HCS12, see the Motorola application note AN2011/D.

Configure switch:

```
--target=hcs12
```

To do a CANopen node running on a microncontroller Motorola MC9S12DP 256, you need :

1. The compiler GNU gcc for HC11, HC12, HCS12 : m6811 -elf.
Download the **release 3.1** at : http://m68hc11.servftp.org/m68hc11_pkg_rpm.php
2. A board with this chip. We are using the T -board from Elektron-ikladen.
3. At least about 40 kBytes of program memory.
4. A tool to flash the memory. (We are using the high cost Lauterbach debugger).

7.1) Running a HCS12 node

7.1.1) Compiling Canfestival:

```
./configure --target=hcs12
```

7.1.2) Compiling and building an example

Enter in the folder of an HCS12 example,

```
make all
```

7.1.3) Flashing the memory :

Use your preferred loader ! If you are using a debugger Lauterbach, you can load the bash file : `trace32_flash_programmer.cmm`. It loads directly the elf file.

7.1.4) Connecting to a serial RS232 console :

Connect the portS(TxD0) of the HCS12 to a console configured at 19200 bauds 8N1, via a Max232 chip to adapt the electrical levels. On Linux, you can use `minicom`. Connecting to a console is useful to read the messages, but not required.

7.1.5) Connecting to the CAN network :

Connect the port CAN0 (pin PM0, PM1) to the network via a CAN controller. On our board, the CAN controller is a PCA82C250 chip.

7.1.6) starting the node :

Press the reset of your HCS12 board.

8 - Example and test program:

The “examples” directory contains some test program you can use as example for your own developments.

8.1) CANOpenShell

This example provides a node that can execute some user commands through `stdin`.

With this example you can:

1. scan network (reset all nodes and display node's bootup message)
2. start / stop /reset a remote node

3. get informations about a remote node
4. read / write a specific entry of a remote node

The node can be started as a master node or a slave node. The only difference is that when is started as a master, all nodes on the network are reseted.

Be careful, the first command must be the "load" command.

```
*****
* CANOpenShell
*
*   MANDATORY COMMAND (must be the first command)
*   load#CanLibraryPath,channel,baudrate,nodeid,type (0:slave, 1:master)
*
* NETWORK: (if nodeid=0x00 : broadcast)
*   ssta#nodeid : Start a node
*   ssto#nodeid : Stop a node
*   srst#nodeid : Reset a node
*   scan : Reset all nodes and print message when bootup
*   wait#seconds : Sleep for n seconds
*
* SDO: (size in bytes)
*   info#nodeid
*   rsdo#nodeid,index,subindex : read sdo
*       ex : rsdo#42,1018,01
*   wsdo#nodeid,index,subindex,size,data : write sdo
*       ex : wsdo#42,6200,01,01,FF
*
* Note: All numbers are hex
*
*   help : Display this menu
*   quit : Quit application
*****
```

Minimal launch command :

```
./CANOpenShell load#libcanfestival_can_peak_linux.so,32,125K,8,0
```

This command start the node as a slave with nodeid 8 at 125K on channel 32.

Advanced launch command :

```
./CANOpenShell load#libcanfestival_can_peak_linux.so,32,125K,8,1 \
help \
wait#5 \
wsdo#42,6200,01,01,FF
```

This command starts the node as a master with nodeid 8 at 125K on channel 32, displays help menu, wait 5 seconds for node's NMT bootup, and write FF value at index 6200, subindex 01 to the remote node with id 42.

8.2) TestMasterSlave

```
*****
* TestMasterSlave *
* *
* A simple example for PC. It does implement 2 CanOpen *
* nodes in the same process. A master and a slave. Both *
* communicate together, exchanging periodically NMT, SYNC, *
* SDO and PDO. Master configure heartbeat producer time *
* at 1000 ms for slave node-id 0x02 by concise DCF. *
* *
* Usage: *
* ./TestMasterSlave [OPTIONS] *
* *
* OPTIONS: *
* -l : Can library ["libcanfestival_can_virtual.so"] *
* *
* Slave: *
* -s : bus name ["0"] *
* -S : 1M,500K,250K,125K,100K,50K,20K,10K,none(disable) *
* *
* Master: *
* -m : bus name ["1"] *
* -M : 1M,500K,250K,125K,100K,50K,20K,10K,none(disable) *
* *
*****
```

Notes about use of concise DCF :

In this example, Master configure heartbeat producer time at 1000 ms for slave node -id 0x02 by concise DCF according DS -302 profile.

Index 0x1F22, sub-index 0x00 of the master OD, correspond to the number of entries. This equal to the maximum possible nodeId (127). Each

sub -index points to the Node -ID of the device, to which the configuration belongs.

To add more parameters configurations to the slave, the value at sub -index 0x02 must be a binary stream (little -endian) following this structure :

```
(UNS32) nb of entries
(UNS16) index parameter 1
(UNS8) sub -index parameter 1
(UNS32) size data parameter 1
(DOMAIN) data parameter 1
(UNS16) index parameter 2
(UNS8) sub -index parameter 2
(UNS32) size data parameter 2
(DOMAIN) data parameter 2
....
(UNS16) index parameter n
(UNS8) sub -index parameter n
(UNS32) size data parameter n
(DOMAIN) data parameter n
```

So the binary value stream to configure heartbeat producer time must be :

```
0100000017100002000000e803
```

The slave node is configured just before the Master entering in Pre_operational state.

8.3) gene_SYNC_HCS12 :

This is a simple CANopen node that only send cyclic SYNC message. It demonstrate implementation on HCS12 based board.

8.4) kerneltest :

Example based on TestMasterSlave slightly modified to suit kernel space requisites. It will do the same as TestMasterSlave but in kernel space sending

kernel messages (displayed by dmesg for example). It is designed as external kernel module implemented as character device. There is a shell script called 'insert.sh', which will insert the module and create a new device file /dev/canf_ktest (used to sending commands to module). To actual sending commands you can use simple console named 'canf_ktest_console'. The module is dependent on a another separate module 'canfestival.ko' implementing CanOpen stack which exports requisite functions. Canfestival.ko module is then dependent on CAN card driver module, by default CAN virtual driver will be loaded. After installing modules (make install), all dependencies are solved automatically by kernel. To run the example type:

```
sh run.sh
```

It will insert required modules, start console, and after quitting console it'll remove modules from kernel.

8.5) TestMasterMicroMod

```
*****
* TestMasterMicroMod *
* *
* A simple example for PC. *
* A CanOpen master that control a MicroMod module: *
* - setup module TPDO 1 transmit type *
* - setup module RPDO 1 transmit type *
* - setup module hearbeatbeat period *
* - disable others TPDOs *
* - set state to operational *
* - send periodic SYNC *
* - send periodic RPDO 1 to Micromod (digital output) *
* - listen Micromod's TPDO 1 (digital input) *
* - Mapping RPDO 1 bit per bit (digital input) *
* *
* Usage: *
* ./TestMasterMicroMod [OPTIONS] *
* *
* OPTIONS: *
* -l : Can library ["libcanfestival_can_virtual.so"] *
* *
* Slave: *
* -i : Slave Node id format [0x01 , 0x7F] *
```

```

*
* Master:
*   -m : bus name ["1"]
*   -M : 1M,500K,250K,125K,100K,50K,20K,10K
*
*****

```

8.6) TestMasterSlaveLSS

```

*****
* TestMasterSlaveLSS
*
* A LSS example for PC. It does implement 3 CanOpen
* nodes in the same process. A master and 2 slaves. All
* communicate together, exchanging periodically NMT, SYNC,
* SDO and PDO. Master configure heartbeat producer time
* at 1000 ms for the slaves by concise DCF.
*
* Usage:
* ./TestMasterSlaveLSS [OPTIONS]
*
* OPTIONS:
*   -l : Can library ["libcanfestival_can_virtual.so"]
*
* SlaveA:
*   -a : bus name ["0"]
*   -A : 1M,500K,250K,125K,100K,50K,20K,10K,none(disable)
*
* SlaveB:
*   -b : bus name ["1"]
*   -B : 1M,500K,250K,125K,100K,50K,20K,10K,none(disable)
*
* Master:
*   -m : bus name ["2"]
*   -M : 1M,500K,250K,125K,100K,50K,20K,10K,none(disable)
*
*****

```

The function used to request LSS services is *configNetworkNode*. It works similar to *writeNetworkDict* and its model is the following:

```
UNS8 configNetworkNode (CO_Data* d, UNS8 command, void *dat1, void* dat2,
```

```
LSSCallback_t Callback)
```

8.7) FastScan

FastScan is a special LSS service that allow the dynamically identification of the slave nodes even if they do not have a valid nodeID. This identification is based on the LSS address, composed by vendor ID, product code, revision number and serial number (refer to the DS305 for more information). The LSS address can be partially known or fully unknown. To represent this fact in Canfestival, we use the structure *lss_fs_transfer_t*. The parameter *FS_LSS_ID* is an array of four elements which represents the four elements of the LSS address. The other parameter, *FS_BitChecked*, is also an array and it represents how many bits of each LSS address element are UNKNOWN. The next example is taken from *TestMasterSlaveLSS*, where only the last two digits (8 bits) of vendor ID and product code are unknown and revision number and serial number are totally unknown.

```
lss_fs_transfer_t lss_fs;
/* The VendorID and ProductCode are partialy known, */
/* except the last two digits (8 bits). */
lss_fs.FS_LSS_ID[0]=Vendor_ID;
lss_fs.FS_BitChecked[0]=8;
lss_fs.FS_LSS_ID[1]=Product_Code;
lss_fs.FS_BitChecked[1]=8;
/* serialNumber and RevisionNumber are unknown, */
/* i.e. the 8 digits (32bits) are unknown. */
lss_fs.FS_BitChecked[2]=32;
lss_fs.FS_BitChecked[3]=32;
res=configNetworkNode(&d,LSS_IDENT_FASTSCAN,&lss_fs,0,CheckLSSAndContinue);
```

9 - Developing a new node

Using provided examples as a base for your new node is generally a good idea. You can also use the provided *.od files as a base for your node object dictionary.

Creating a new CANopen node implies to define the Object Dictionary of this node. For that, developer has to provide a C file. This C file contains the definition of all dictionary entries, and some kind of index table that helps the stack to access some entries directly.

9.1) Using Dictionary Editor GUI

The Object Dictionary Editor is a WxPython based GUI that is used to create the C file needed to create a new CANopen node.

9.1.1) Installation and usage on Linux

You first have to download and install Gnosis XML modules. This is automated by a Makefile rule.

```
cd objdictgen
make
```

Now start the editor.

```
python objdictedit.py [od files...]
```

9.1.2) Installation and usage on Windows

Install Python (at least version 2.4) and wxPython (at least version 2.6.3.2).

Cygwin users can install Gnosis XML utils the same as Linux use. Just call make.

```
cd objdictgen
make
```

Others will have to download and install Gnosis XML by hand :

```
Gnosis Utils:
http://freshmeat.net/projects/gnosisxml/
http://www.gnosis.cx/download/
Get latest version.
```

Download CanFestival archive and uncompress it. Use windows file explorer to go into CanFestival3\objdictgen, and double -click on objdictedit.py.

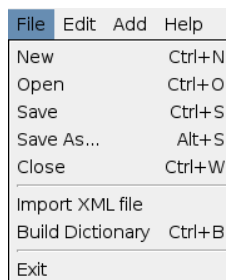
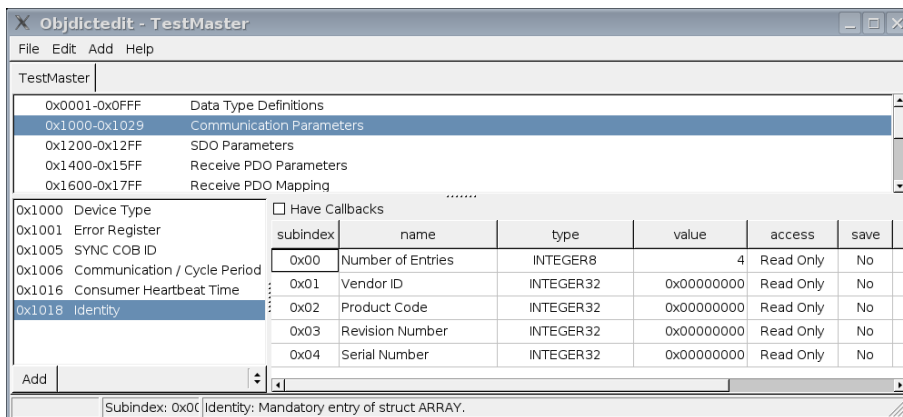
9.1.3) About

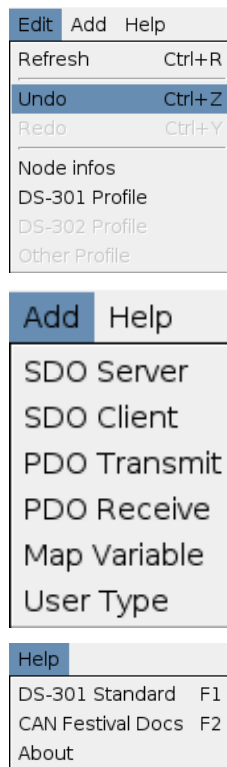
The Object Dictionary editor GUI is a python application that use the Model-View-Controller design pattern. It depends on WxPython to display view on any supported platform.



9.1.4) Main view

Top list let you choose dictionary section, bottom left list is the selected index in that dictionary, and bottom right list are edited sub -indexes.





9.1.5) New node

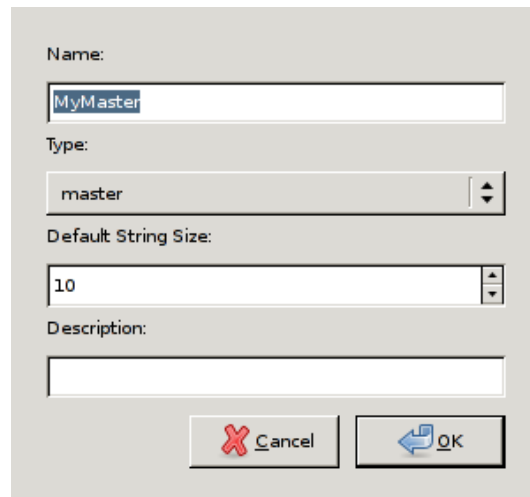
Edit your node name and type. Choose your inherited specific profile.

The 'New node' configuration dialog box contains the following elements:

- Type:** A dropdown menu currently showing 'master'.
- Name:** A text input field containing 'MyMaster'.
- Profile:** A dropdown menu currently showing 'DS-401'.
- Network Management:** Three radio button options: 'None', 'Node Guarding', and 'Heartbeat' (which is selected).
- Options:** Four checkboxes: 'DS-302 Profile' (unchecked), 'Generate SYNC' (checked), 'Emergency support' (unchecked), and 'Save Configuration' (unchecked).
- Description:** A large empty text area for entering a description.
- Buttons:** 'Cancel' and 'OK' buttons at the bottom right.

9.1.6) Node info

Edit your node name and type.

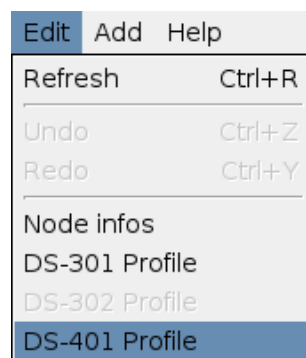


The screenshot shows a dialog box titled "Node info" with the following fields and controls:

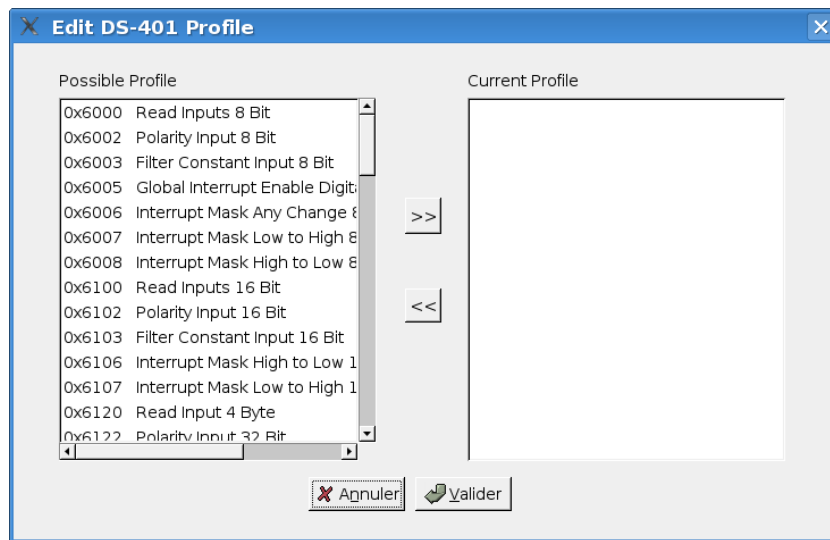
- Name:** A text input field containing "MyMaster".
- Type:** A dropdown menu currently set to "master".
- Default String Size:** A spin box set to "10".
- Description:** An empty text input field.
- Buttons:** "Cancel" (with a red X icon) and "OK" (with a blue arrow icon).

9.1.7) Profile editor

Chose the used profile to edit.

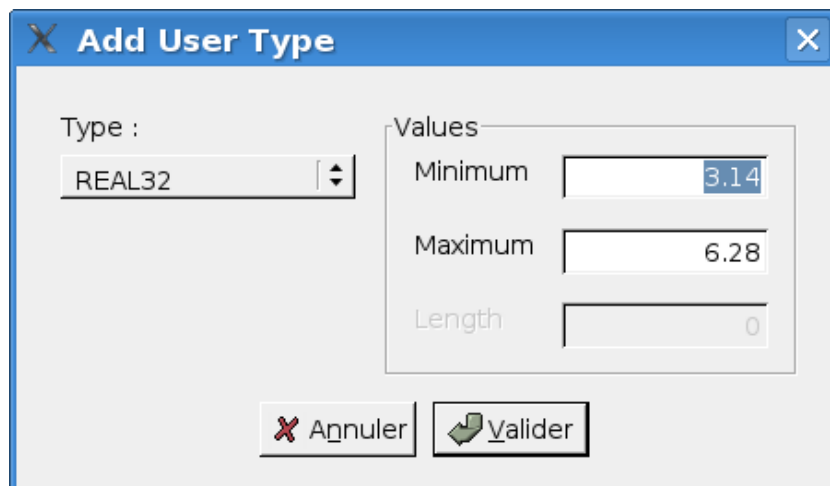


Pick up optional chosen profile entries.



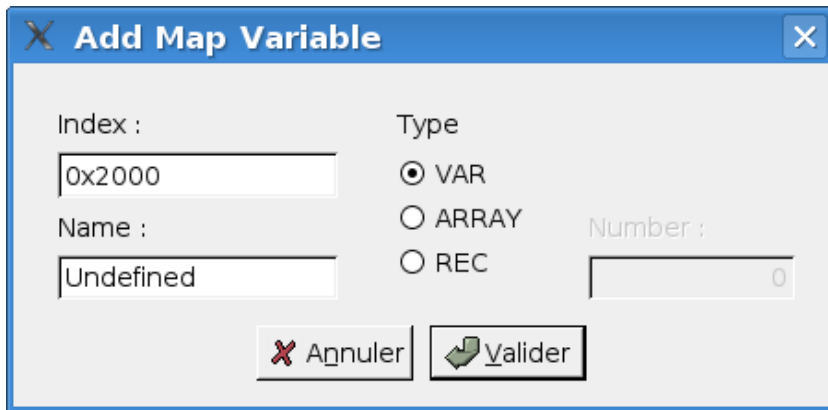
9.1.8) User types

Use User Types to implement value boundaries, and string length



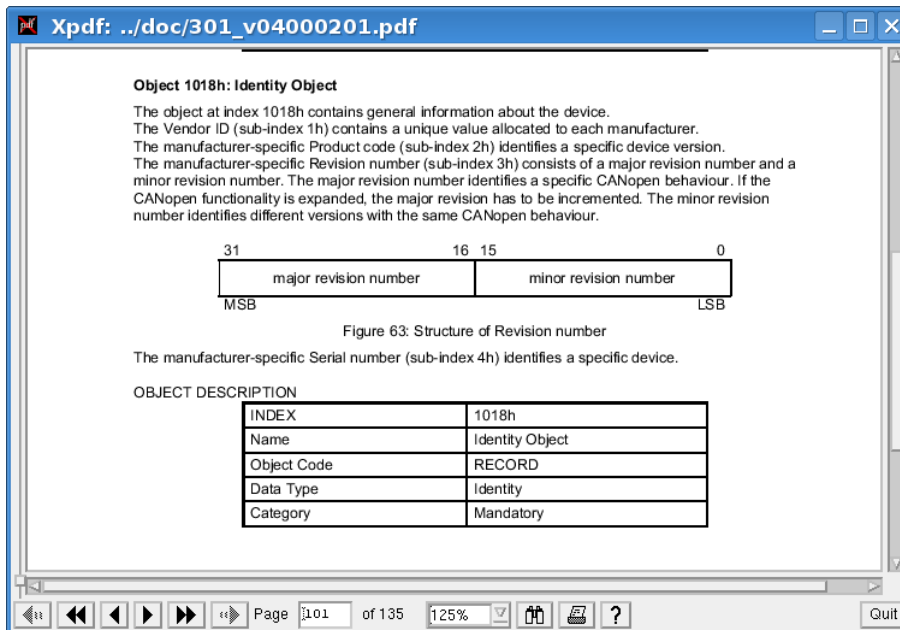
9.1.9) Mapped variable

Add your own specific dictionary entries and associated mapped variables.



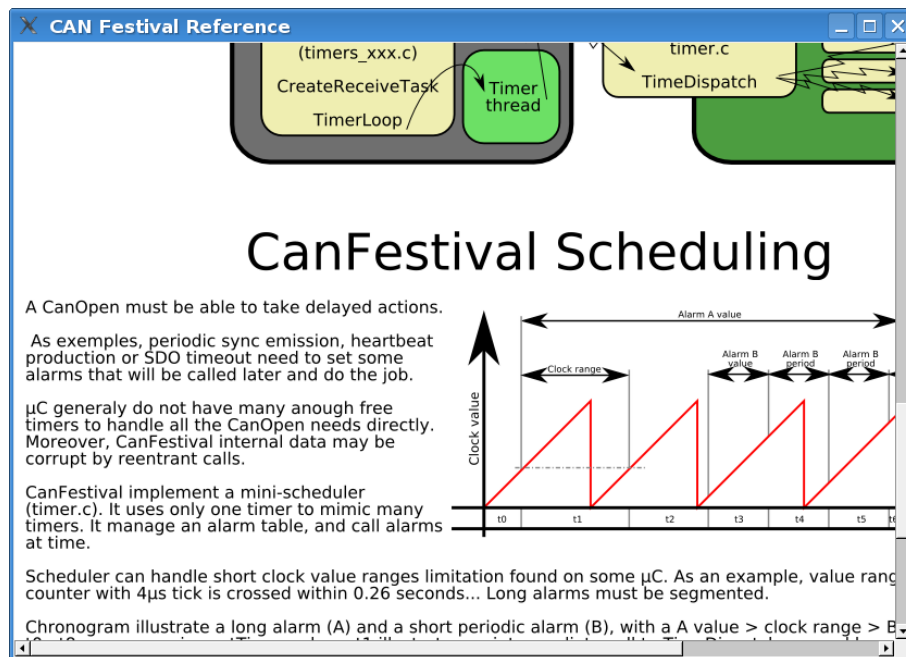
9.1.10) Integrated help

Using F1 key, you can get context sensitive help.



In order to do that, official 301_v04000201.pdf file must be placed into doc/ directory, and xpdf must be present on your system.

F2 key open HTML CanFestival help.



CanFestival Scheduling

A CanOpen must be able to take delayed actions.

As examples, periodic sync emission, heartbeat production or SDO timeout need to set some alarms that will be called later and do the job.

μ C generally do not have many enough free timers to handle all the CanOpen needs directly. Moreover, CanFestival internal data may be corrupt by reentrant calls.

CanFestival implement a mini-scheduler (timer.c). It uses only one timer to mimic many timers. It manage an alarm table, and call alarms at time.

Scheduler can handle short clock value ranges limitation found on some μ C. As an example, value range counter with 4μ s tick is crossed within 0.26 seconds... Long alarms must be segmented.

Chronogram illustrate a long alarm (A) and a short periodic alarm (B), with a A value > clock range > B.

The diagram shows a window titled "CAN Festival Reference" with two panes. The left pane, labeled "(timers_XXX.c)", contains "CreateReceiveTask" and "TimerLoop". The right pane, labeled "timer.c", contains "TimeDispatch". A "Timer thread" is shown as a green box between them. Below the panes is a graph titled "CanFestival Scheduling". The graph plots "Clock value" on the y-axis against time on the x-axis (marked 10 to 15). A red sawtooth wave represents the clock value. A long horizontal arrow labeled "Alarm A value" spans from approximately time 10.5 to 14.5. Three shorter horizontal arrows labeled "Alarm B value" and "Alarm B period" are shown as vertical segments at approximately time 11.5, 13.5, and 14.5.

9.2) Generating the object Dictionary

Once object dictionary has been edited and saved, you have to generate object dictionary C code for your CanFestival node.

9.2.1) With GUI

Menu entry "File/Build Dictionary".

New	Ctrl+N
Open	Ctrl+O
Save	Ctrl+S
Save As...	Alt+S
Close	Ctrl+W

Import XML file	
Build Dictionary	Ctrl+B

Exit	

Choose C file to create or overwrite. Header file will be also created with the same prefix as C file.

9.2.2) With command line

Usage of objdictgen.py :

```
python objdictgen.py XMLFilePath CfilePath
```

10 - FAQ

10.1) General

10.1.1) Does the code compiles on Windows ?

Yes, with both Cygwin and Visual Studio C++.

Because CANopen layer is coded with C, put a compilation option /TC or /TP if you plan to mix C++ files. See the MSDN documentation about that.

10.1.2) How to fit the library to an other microcontroller ?

First, be sure that you have at least 40K bytes of program memory, and about 2k of RAM.

You have to create target specific interface to HW resources. Take model on bundled interfaces provided in drivers/ and create your own interface. You also have to update Makefile.in files for target specific cflags and options. Choose `-target=` configure switch to compile your specific interface.

You are welcome to contribute -back your own interfaces! Other Canfestival users will use it and provide feedback, tests and enhancements.

10.1.3) Is CanFestival3 conform to DS301 v.4.02 ?

Thanks to Philippe Foureys (IUT of Valence), a slave node have been tested with the National Instrument CANopen Conformance Test. It passed the test with success.

Some very small unconformity have been found in very unusual situations, for example in the SDO code response to wrong messages.

10.2) LINUX

10.2.1) How to use a Peak system CAN board ?

Just install peak driver and then compile and install Canfestival. Peak driver is detected at compile time.

10.2.2) How to use an unsupported CAN board ?

You have to install the specific driver on your system, with necessary libs and headers.

Use `can_peak.c/h` or `can_virtual.c/h` as an example, and adapt it to your driver API.

Execute configure script and choose `-can=mydriver`

10.3) Win32

Compatibility:

1. Code was compiled MS VisualStudio 2003.NET and VisualStudio 2005.NET for WindowsXP with ANSI and UNICODE configurations and for WindowsCE 5.0.
2. Some preliminary testing was done, but not enough to be used in mission critical projects.

Additional Features:

1. Non -integral integers support implementation UNS24, UNS40, UNS48 etc.
2. When enable debug output with `DEBUG_WAR_CONSOLE_ON` or `DEBUG_ERR_CONSOLE_ON`, you can navigate in CanFestival source code by double clicking at diagnostic lines in VisualStudio.NET 200X Debug Output Window.

Custom size integral types such as `INTEGER24`, `UNS40`, `INTEGER56` etc. have been defined as 64 bits integers. You will need to replace `sizeof(TYPE)` operators to `sizeof_TYPE` definitions in generated code, i.e. replace `sizeof(UNS40)` with `sizeof_UN40`.

10.4) HCS12

10.4.1) Which board are you using ?

A T -board from elektronikladen with a MC9S12DP256 or MC9S12DG256.

10.4.2) Does the code compile with an other compiler than GNU gcc ?

It is known to work with Metrowerks CodeWarrior. Here are some tips from Philippe Foureys. :

a) Interrupt functions**i) Code for GCC:**

```
// prototype
void __attribute__((interrupt))timer3Hdl(void):
// function
void __attribute__((interrupt))timer3Hdl(void){...}
```

ii) Code for CodeWarrior

```
// protoype
void interrupt timer3Hdl(void);
// function
#pragma CODE_SEG__NEAR_SEG_NON_BANKED
void interrupt timer3Hdl(void)
{...}
#pragma CODE_SEG_DEFAULT
```

b) Interrupt lock, unlock**i) Code for GCC**

```
void unlock (void)
{
    __asm__ __volatile__("cli");
}
void lock (void)
{
    unsigned short mask;
    __asm__ __volatile__("tpa\n\tsei":"=d"(mask));
}
```

ii) Code for CodeWarrior

```
void unlock (void)
{
    __asm("cli");
}
void lock (void)
{
```

```

    unsigned short mask;
    __asm
    {
        tpa:tsei:="d"(mask);
    }
}

```

c) Initialize function

i) Code for GCC

```

void initCanHCS12 (void)
{
    //Init the HCS12 microcontroller for CanOpen
    initHCS12();
    // Init the HCS12 CAN driver
    const canBusInit bi0 = {
        0,    /* no low power          */
        0,    /* no time stamp          */
        1,    /* enable MSCAN          */
        0,    /* clock source : oscillator (In fact, it is not used) */
        0,    /* no loop back          */
        0,    /* no listen only        */
        0,    /* no low pass filter for wk up */
        CAN_Baudrates[CAN_BAUDRATE_250K],
        {
            0x00,    /* Filter on 16 bits.
                    See Motorola Block Guide V02.14 fig 4-3 */
            0x00, 0xFF, /* filter 0 hight accept all msg */
            0x00, 0xFF, /* filter 0 low accept all msg */
            0x00, 0xFF, /* filter 1 hight filter all of msg */
            0x00, 0xFF, /* filter 1 low filter all of msg */
            0x00, 0xFF, /* filter 2 hight filter most of msg */
            0x00, 0xFF, /* filter 2 low filter most of msg */
            0x00, 0xFF, /* filter 3 hight filter most of msg */
            0x00, 0xFF, /* filter 3 low filter most of msg */
        }
    };
};

```

ii) Code for CodeWarrior

```

void initCanHCS12 (void)
{
    //Init the HCS12 microcontroller for CanOpen
    initHCS12();
    // Init the HCS12 CAN driver
    const canBusInit bi0 = {
        0,    /* no low power          */
        0,    /* no time stamp          */
        1,    /* enable MSCAN          */
        0,    /* clock source : oscillator (In fact, it is not used) */
        0,    /* no loop back          */
        0,    /* no listen only        */
        0,    /* no low pass filter for wk up */
        {
            1, /* clksrc */
            3, /* brp    */
            0, /* sjw    */
            0, /* samp   */
            1, /* tseg2  */
            12, /* tseg1 */
        },
        {
            0x00,    /* Filter on 16 bits.
                See Motorola Block Guide V02.14 fig 4-3 */
            0x00, 0xFF, /* filter 0 hight accept all msg */
            0x00, 0xFF, /* filter 0 low accept all msg */
            0x00, 0xFF, /* filter 1 hight filter all of msg */
            0x00, 0xFF, /* filter 1 low filter all of msg */
            0x00, 0xFF, /* filter 2 hight filter most of msg */
            0x00, 0xFF, /* filter 2 low filter most of msg */
            0x00, 0xFF, /* filter 3 hight filter most of msg */
            0x00, 0xFF, /* filter 3 low filter most of msg */
        }
    };
};

```

10.4.3) Does the code works in banked memory ?

No. Today it seems that the port of gcc is bogged for using the banked memory. So, unfortunately, we are limited to 48 Kbytes of memory code.

10.4.4) What GCC version are you using ?

We are using the stable RPM release 2.2 :

1. GNU Gcc 3.0.4. Build 20030501
2. Newlib 1.10.0 Build 20030421
3. GNU Binutils 2.12.1 Build 20030427

11 - Documentation resources

11.1) CIA : Can in Automation

<http://www.can-cia.de>

11.2) Resources and training in CANopen

<http://www.esacademy.com>

11.3) Elektronikladen HCS12 T -board

http://www.elektronikladen.de/en_hcs12tb.html

11.4) Gnu gcc compiler for HC12

http://m68hc11.serveftp.org/m68hc11_port.php

11.5) Motorola documentation on HC12

http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=MC9S12DP256

11.6) Lauterbach debugger for HC12

<http://www.lauterbach.com>

11.7) Python language

<http://www.python.org>

12 - About the project

12.1) Contributors



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12.2) Getting support

Send your feedback and bug reports to canfestival-devel@lists.sourceforge.net.

For commercial support, training and specific integration and developments, please ask LOLITECH (see contributors).

12.3) Contributing

You are free to contribute your specific interfaces back to the project. This way, you can hope to get support from CanFestival users community.

Please send your patch to canfestival-devel@lists.sourceforge.net.

Feel free to create some new predefined DS -4xx profiles (*.prf) in objdictgen/config, as much as possible respectful to the official specifications.

12.4) License

All the project is licensed with LGPL. This mean you can link CanFestival with any code without being obliged to publish it.

```
#This file is part of CanFestival, a library implementing CanOpen Stack.
#
#Copyright (C): Edouard TISSERANT, Francis DUPIN and Laurent BESSARD
#
#See COPYING file for copyrights details.
#
#This library is free software; you can redistribute it and/or
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#version 2.1 of the License, or (at your option) any later version.
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#License along with this library; if not, write to the Free Software
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```