

# EPICS Multi-Core Utilities

Generated by Doxygen 1.8.1.2

Mon Nov 12 2012 14:39:37



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# Chapter 1

## EPICS Multi-Core Utilities

### 1.1 Scope of this Document

This API documentation covers version 1.0 of the EPICS Multi-Core Utilities.

### 1.2 Sources

Releases can be found at <http://sourceforge.net/projects/epics/files/mcoreutils/>

The sources are versioned using Mercurial. They can be viewed at <http://epics.hg.sourceforge.net/hgweb/epics/mcoreutils/> or checked out using

```
hg clone http://epics.hg.sourceforge.net:8000/hgroot/epics/mcoreutils
```

### 1.3 Requirements

- Linux operating system
- EPICS BASE  $\geq$  3.15.0.1

### 1.4 Introduction

The EPICS Multi-Core Utilities library contains tools that allow tweaking of real-time parameters for EPICS IOC threads running on multi-core processors under the Linux operating system.

These tools are intended to set up multi-core IOCs for fast controllers, by:

- Confining either parts or the complete EPICS IOC onto a subset of the available cores, allowing hard real-time applications and threads to run on dedicated cores.
- Changing priorities of callback, driver or communication threads with respect to database processing.
- Selecting real-time scheduling policy (FIFO or Round-Robin) for selected threads.

#### 1.4.1 Advanced Thread Show Routines

An extended version of the `epicsThreadShow()` command, showing scheduling policy and CPU affinity in addition to the usual output.

Details can be found in the documentation for module [Real-Time threadShow Routines](#).

### 1.4.2 Rule Based Real-Time Property Manipulation

A module allowing to specify rules, which consist of a regular expression to match the thread name against, and a set of commands that allow to specify the real-time properties of a thread.

Whenever the EPICS IOC starts a thread, its name is matched against all existing rules, and for matching rules the commands are applied.

Details can be found in the documentation for module [Rule-Based Thread Properties](#).

#### Warning

The default priorities of the EPICS IOC threads are well-chosen. They have been proven to ensure reliable IOC operation and communication, in many installations, under a variety of circumstances.

Manipulating the real-time properties, especially scheduling policies and priorities, may have unwanted side effects. Use this feature sparingly, and test well.

## Chapter 2

# Module Index

### 2.1 Modules

Here is a list of all modules:

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## Chapter 3

# File Index

### 3.1 File List

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# Chapter 4

## Module Documentation

### 4.1 Real-Time threadShow Routines

Add two new threadShow functions that show scheduling policy and CPU affinity.

#### Files

- file [threadShow.c](#)  
*New threadShow showing real-time properties.*

#### Functions

- epicsShareFunc void [mcoreThreadShowInit](#) (void)  
*Initialization routine.*
- epicsShareFunc void [mcoreThreadShow](#) (epicsThreadId thread, unsigned int level)  
*iocShell: Show thread info for one thread.*
- epicsShareFunc void [mcoreThreadShowAll](#) (unsigned int level)  
*iocShell: Show thread info for all threads.*

#### 4.1.1 Detailed Description

Add two new threadShow functions that show scheduling policy and CPU affinity. Adds two new threadShow functions that, in addition to the properties shown by `epicsThreadShow()` and `epicsThreadShowAll()`, print the scheduling policy, and the CPU affinity of each thread.

Uses the `epicsThreadMap()` call to have a hook function being called for every thread, which prints out the thread properties.

#### 4.1.2 Function Documentation

##### 4.1.2.1 epicsShareFunc void mcoreThreadShow ( epicsThreadId thread, unsigned int level )

**iocShell:** Show thread info for one thread.

Sets the global thread and level variables, and calls the map function.

#### Parameters

<i>thread</i>	id of thread to show
<i>level</i>	verbosity level

## IOC Shell

**mcoreThreadShow thread level**

thread	thread name or id
level	verbosity level

Definition at line 121 of file threadShow.c.

**4.1.2.2 epicsShareFunc void mcoreThreadShowAll ( unsigned int *level* )**

**iocShell:** Show thread info for all threads.

## Parameters

<i>level</i>	verbosity level
--------------	-----------------

## IOC Shell

**mcoreThreadShowAll level**

level	verbosity level
-------	-----------------

Definition at line 135 of file threadShow.c.

**4.1.2.3 epicsShareFunc void mcoreThreadShowInit ( void )**

Initialization routine.

Must be called before using any of the other functions, which is done when registering the iocsh commands.

Definition at line 152 of file threadShow.c.

## 4.2 Rule-Based Thread Properties

Allow user-specified rules that modify real-time properties of EPICS threads.

### Files

- file [threadRules.c](#)  
*Rule-based modification of thread real-time properties.*

### Functions

- `epicsShareFunc void mcoreThreadModify (epicsThreadId id, const char *policy, const char *priority, const char *cpus)`  
*iocShell: Modify a thread's real-time properties.*
- `epicsShareFunc void mcoreThreadRulesInit ()`  
*Initialization routine.*
- `epicsShareFunc long mcoreThreadRuleAdd (const char *name, const char *policy, const char *priority, const char *cpus, const char *pattern)`  
*iocShell: Add or replace a thread rule.*
- `epicsShareFunc void mcoreThreadRuleDelete (const char *name)`  
*iocShell: Delete a thread rule.*
- `epicsShareFunc void mcoreThreadRulesShow (void)`  
*iocShell: Print a comprehensive list of the thread rules.*

### 4.2.1 Detailed Description

Allow user-specified rules that modify real-time properties of EPICS threads. Implements a library that uses rules to modify real-time properties of EPICS threads:

- *Scheduling policy*  
Scheduling mechanism used for this thread. When POSIX scheduling is enabled, the default mechanism is `SCHED_FIFO`, but `SCHED_OTHER` and `SCHED_RR` are also supported.
- *Scheduling priority*  
OSI priority value that gets converted to the system's real-time priority schema.
- *CPU Affinity*  
Set of CPUs that this thread is allowed to run on.

This is achieved by creating a linked list of rules, which consist of a regular expression pattern and modification instructions. A hook function is added to the EPICS thread creation module. The hook is called from every thread as part of its creation, matches the regular expression patterns of all rules against the name of the newly created thread, and applies the modifications of all rules that match.

### See Also

See man pages for [pthread\\_setschedparam\(3\)](#) and [sched\\_setscheduler\(2\)](#) for details on scheduling policy and priority, [pthread\\_setaffinity\\_np\(3\)](#) and [sched\\_setaffinity\(2\)](#) for details on CPU affinity.

### Configuration Files

The module tries to read a system configuration file (default: `/etc/rtrules`) and a user configuration file (default: `$HOME/.rtrules`) to create the initial list of thread rules.

The file format is based on the format of the `/etc/rtgroups` file on RHEL-MRG. Each line has the format

**name:policy:priority:affinity:pattern**

name	name of the rule
policy	scheduling policy to set for the thread (first letter, not case sensitive), * = don't change
priority	scheduling priority to set for the thread (a + or – sign adds to the current priority), * = don't change
affinity	CPUs to set the thread's affinity to (use , and – to specify multiple CPUs and ranges, e.g. 0,3-5), * = don't change
pattern	regular expression pattern to match thread names against, see man page for <a href="#">regex(7)</a> for details

Lines starting with # (comments), and empty lines (containing only whitespace) are ignored.

#### Environment Variables

**EPICS\_MCORE\_SYSCONFIG** name of system configuration file (default: `/etc/rtrules`)

**EPICS\_MCORE\_USERCONFIG** name of user configuration file, relative to the HOME directory (default: `.rtrules`)

#### Known Issues

A thread calling `epicsThreadSetPriority()` to set its priority while running may override the priorities defined in the rules at any time.

## 4.2.2 Function Documentation

**4.2.2.1** `epicsShareFunc void mcoreThreadModify ( epicsThreadId id, const char * policy, const char * priority, const char * cpus )`

**iocShell:** Modify a thread's real-time properties.

#### Parameters

<i>id</i>	EPICS thread id
<i>policy</i>	scheduling policy to set (* = don't change)
<i>priority</i>	scheduling priority (OSI) to set (a + or – sign adds to the current priority, * = don't change)
<i>cpus</i>	cpuset specification to set (use , and – to specify multiple CPUs and ranges, * = don't change)

#### IOC Shell

**mcoreThreadModify thread policy priority cpus**

thread	thread name or id
policy	scheduling policy to set (* = don't change)
priority	scheduling priority (OSI) to set (a + or – sign adds to the current priority, * = don't change)
cpus	cpuset specification to set (use , and – to specify multiple CPUs and ranges, * = don't change)

Definition at line 285 of file `threadRules.c`.

**4.2.2.2** `epicsShareFunc long mcoreThreadRuleAdd ( const char * name, const char * policy, const char * priority, const char * cpus, const char * pattern )`

**iocShell:** Add or replace a thread rule.

#### Parameters

<i>name</i>	rule name (identifier)
<i>policy</i>	scheduling policy to set (* = don't change)
<i>priority</i>	scheduling priority (OSI) to set (a + or – sign adds to the current priority, * = don't change)
<i>cpus</i>	cpuset specification to set (use , and – to specify multiple CPUs and ranges, * = don't change)
<i>pattern</i>	<b>regex (7)</b> pattern to match thread names against

#### Returns

(OK, ERROR) as (0,-1)

#### IOC Shell

**mcoreThreadRuleAdd name policy priority cpus pattern**

name	rule name (identifier)
policy	scheduling policy to set (* = don't change)
priority	scheduling priority (OSI) to set (a + or – sign adds to the current priority, * = don't change)
cpus	cpuset specification to set (use , and – to specify multiple CPUs and ranges, * = don't change)
pattern	<b>regex (7)</b> pattern to match thread names against

Definition at line 107 of file threadRules.c.

**4.2.2.3** `epicsShareFunc void mcoreThreadRuleDelete ( const char * name )`

**iocShell:** Delete a thread rule.

#### Parameters

<i>name</i>	name (identifier) of the rule to delete
-------------	---

#### IOC Shell

**mcoreThreadRuleDelete name**

name	name (identifier) of the rule to delete
------	---

Definition at line 138 of file threadRules.c.

**4.2.2.4** `epicsShareFunc void mcoreThreadRulesInit ( )`

Initialization routine.

Must be called before using any of the other functions, which is done when registering the iocsh commands.

Definition at line 373 of file threadRules.c.

**4.2.2.5** `epicsShareFunc void mcoreThreadRulesShow ( void )`

**iocShell:** Print a comprehensive list of the thread rules.

Rule names are shortened to 16 characters.

IOC Shell

**mcoreThreadRulesShow**

Definition at line 163 of file threadRules.c.



## Chapter 5

# File Documentation

### 5.1 mcoreutils.h File Reference

```
#include <unistd.h>
#include <epicsThread.h>
#include <shareLib.h>
```

#### Functions

- epicsShareFunc void [mcoreThreadShowInit](#) (void)  
*Initialization routine.*
- epicsShareFunc void [mcoreThreadShow](#) (epicsThreadId thread, unsigned int level)  
**iocShell:** Show thread info for one thread.
- epicsShareFunc void [mcoreThreadShowAll](#) (unsigned int level)  
**iocShell:** Show thread info for all threads.
- epicsShareFunc void [mcoreThreadModify](#) (epicsThreadId id, const char \*policy, const char \*priority, const char \*cpus)  
**iocShell:** Modify a thread's real-time properties.
- epicsShareFunc void [mcoreThreadRulesInit](#) ()  
*Initialization routine.*
- epicsShareFunc long [mcoreThreadRuleAdd](#) (const char \*name, const char \*policy, const char \*priority, const char \*cpus, const char \*pattern)  
**iocShell:** Add or replace a thread rule.
- epicsShareFunc void [mcoreThreadRuleDelete](#) (const char \*name)  
**iocShell:** Delete a thread rule.
- epicsShareFunc void [mcoreThreadRulesShow](#) (void)  
**iocShell:** Print a comprehensive list of the thread rules.

#### 5.1.1 Detailed Description

##### Author

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Definition in file [mcoreutils.h](#).

## 5.2 shellCommands.c File Reference

iocShell registration of MCoreUtils commands.

```
#include <unistd.h>
#include <stdlib.h>
#include <iocsh.h>
#include <epicsExport.h>
#include <epicsThread.h>
#include "mcoreutils.h"
```

### 5.2.1 Detailed Description

iocShell registration of MCoreUtils commands.

#### Author

Ralph Lange [Ralph.Lange@gmx.de](mailto:Ralph.Lange@gmx.de)

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Definition in file [shellCommands.c](#).

## 5.3 threadRules.c File Reference

Rule-based modification of thread real-time properties.

```
#include <stdlib.h>
#include <stdio.h>
#include <pthread.h>
#include <sys/types.h>
#include <regex.h>
#include <string.h>
#include <ellLib.h>
#include <envDefs.h>
#include <errlog.h>
#include <epicsStdio.h>
#include <epicsMath.h>
#include <epicsThread.h>
#include <epicsMutex.h>
#include <shareLib.h>
#include "utils.h"
#include "mcoreutils.h"
```

- typedef struct threadRule [threadRule](#)  
*A thread rule.*
- long [mcoreThreadRuleAdd](#) (const char \*name, const char \*policy, const char \*priority, const char \*cpus, const char \*pattern)  
*Add or replace a thread rule.*
- void [mcoreThreadRuleDelete](#) (const char \*name)  
*Delete a thread rule.*
- void [mcoreThreadRulesShow](#) (void)  
*Print a comprehensive list of the thread rules.*
- void [mcoreThreadModify](#) (epicsThreadId id, const char \*policy, const char \*priority, const char \*cpus)  
*Modify a thread's real-time properties.*
- void [mcoreThreadRulesInit](#) (void)  
*Initialization routine.*

### 5.3.1 Detailed Description

Rule-based modification of thread real-time properties.

#### Author

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Definition in file [threadRules.c](#).

### 5.3.2 Typedef Documentation

#### 5.3.2.1 typedef struct threadRule threadRule

A thread rule.

Used to manipulate real-time properties when threads are started. The thread rules are kept in a linked list.

## 5.4 threadShow.c File Reference

New threadShow showing real-time properties.

```
#include <stdlib.h>
#include <sched.h>
#include <string.h>
#include <pthread.h>
#include <ellLib.h>
#include <errlog.h>
#include <epicsStdio.h>
#include <epicsEvent.h>
#include <epicsThread.h>
#include <epicsMath.h>
#include <shareLib.h>
#include "utils.h"
#include "mcoreutils.h"
```

- void [mcoreThreadShow](#) (epicsThreadId thread, unsigned int level)  
*Show thread info for one thread.*
- void [mcoreThreadShowAll](#) (unsigned int level)  
*Show thread info for all threads.*
- void [mcoreThreadShowInit](#) (void)  
*Initialization routine.*

### 5.4.1 Detailed Description

New threadShow showing real-time properties.

#### Author

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Definition in file [threadShow.c](#).

## 5.5 utils.c File Reference

Utility functions for MCoreUtils.

```
#include <stdlib.h>
#include <stdio.h>
#include <sched.h>
#include <string.h>
#include <errlog.h>
#include "utils.h"
```

### Functions

- void [strToCpuset](#) (cpu\_set\_t \*cpuset, const char \*spec)  
*Convert a cpuset string specification (e.g. "0,2-3") to a cpuset.*
- void [cpusetToStr](#) (char \*set, size\_t len, const cpu\_set\_t \*cpuset)  
*Convert a cpuset into its string specification (e.g. "0,2-3").*
- const char \* [policyToStr](#) (const int policy)  
*Convert scheduling policy to string.*
- int [strToPolicy](#) (const char \*string)  
*Convert string policy specification to policy.*

### Variables

- epicsShareDef int [cpuDigits](#)  
*Number of digits needed for a single CPU spec.*

### 5.5.1 Detailed Description

Utility functions for MCoreUtils.

#### Author

Ralph Lange [Ralph.Lange@gmx.de](mailto:Ralph.Lange@gmx.de)

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Definition in file [utils.c](#).

### 5.5.2 Function Documentation

#### 5.5.2.1 void cpusetToStr ( char \* *set*, size\_t *len*, const cpu\_set\_t \* *cpuset* )

Convert a cpuset into its string specification (e.g. "0,2-3").

##### Parameters

<i>set</i>	output buffer to write into
<i>len</i>	length of <i>set</i>
<i>cpuset</i>	cpuset to convert

Definition at line 59 of file [utils.c](#).

#### 5.5.2.2 const char\* policyToStr ( const int *policy* )

Convert scheduling policy to string.

##### Parameters

<i>policy</i>	policy to convert
---------------	-------------------

##### Returns

string representation

Definition at line 96 of file [utils.c](#).

#### 5.5.2.3 void strToCpuset ( cpu\_set\_t \* *cpuset*, const char \* *spec* )

Convert a cpuset string specification (e.g. "0,2-3") to a cpuset.

##### Parameters

<i>cpuset</i>	cpuset to write into
<i>spec</i>	specification string

Definition at line 29 of file [utils.c](#).

#### 5.5.2.4 int strToPolicy ( const char \* *string* )

Convert string policy specification to policy.

##### Parameters

<i>string</i>	string policy specification
---------------	-----------------------------

##### Returns

policy value, or -1 on error

Definition at line 124 of file utils.c.

### 5.5.3 Variable Documentation

#### 5.5.3.1 epicsShareDef int cpuDigits

Number of digits needed for a single CPU spec.

Set in [mcoreThreadShowInit\(\)](#).

Definition at line 21 of file utils.c.

## 5.6 utils.h File Reference

Header file for [utils.c](#).

```
#include <sched.h>
#include <unistd.h>
#include <errlog.h>
```

### Macros

- #define [NO\\_OF\\_CPUS](#) sysconf(\_SC\_NPROCESSORS\_CONF)
- #define [checkStatus](#)(status, message)

### Functions

- void [strToCpuset](#) (cpu\_set\_t \*cpuset, const char \*spec)  
*Convert a cpuset string specification (e.g. "0,2-3") to a cpuset.*
- void [cpusetToStr](#) (char \*set, size\_t len, const cpu\_set\_t \*cpuset)  
*Convert a cpuset into its string specification (e.g. "0,2-3").*
- const char \* [policyToStr](#) (const int policy)  
*Convert scheduling policy to string.*
- int [strToPolicy](#) (const char \*string)  
*Convert string policy specification to policy.*

### Variables

- int [cpuDigits](#)  
*Number of digits needed for a single CPU spec.*

### 5.6.1 Detailed Description

Header file for [utils.c](#).

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Definition in file [utils.h](#).

### 5.6.2 Macro Definition Documentation

#### 5.6.2.1 #define checkStatus( *status*, *message* )

##### Value:

```
if((status)) {\
    errlogPrintf("%s error %s\n", (message), strerror((status))); \
}
```

Definition at line 22 of file [utils.h](#).

#### 5.6.2.2 #define NO\_OF\_CPUS sysconf(\_SC\_NPROCESSORS\_CONF)

Definition at line 20 of file [utils.h](#).

### 5.6.3 Function Documentation

#### 5.6.3.1 void cpusetToStr ( *char \* set*, *size\_t len*, *const cpu\_set\_t \* cpuset* )

Convert a cpuset into its string specification (e.g. "0,2-3").

##### Parameters

<i>set</i>	output buffer to write into
<i>len</i>	length of <i>set</i>
<i>cpuset</i>	cpuset to convert

Definition at line 59 of file [utils.c](#).

#### 5.6.3.2 const char\* policyToStr ( *const int policy* )

Convert scheduling policy to string.

##### Parameters

<i>policy</i>	policy to convert
---------------	-------------------

**Returns**

string representation

Definition at line 96 of file utils.c.

**5.6.3.3 void strToCpuset ( cpu\_set\_t \* *cpuset*, const char \* *spec* )**

Convert a cpuset string specification (e.g. "0,2-3") to a cpuset.

**Parameters**

<i>cpuset</i>	cpuset to write into
<i>spec</i>	specification string

Definition at line 29 of file utils.c.

**5.6.3.4 int strToPolicy ( const char \* *string* )**

Convert string policy specification to policy.

**Parameters**

<i>string</i>	string policy specification
---------------	-----------------------------

**Returns**

policy value, or -1 on error

Definition at line 124 of file utils.c.

**5.6.4 Variable Documentation****5.6.4.1 int cpuDigits**

Number of digits needed for a single CPU spec.

Set in [mcoreThreadShowInit\(\)](#).

Definition at line 21 of file utils.c.



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