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## Dmaengine overview



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This article provides basic information about the DMA engine and how STM32 DMA, DMAMUX and MDMA drivers are plugged into it.

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## 1 Framework purpose

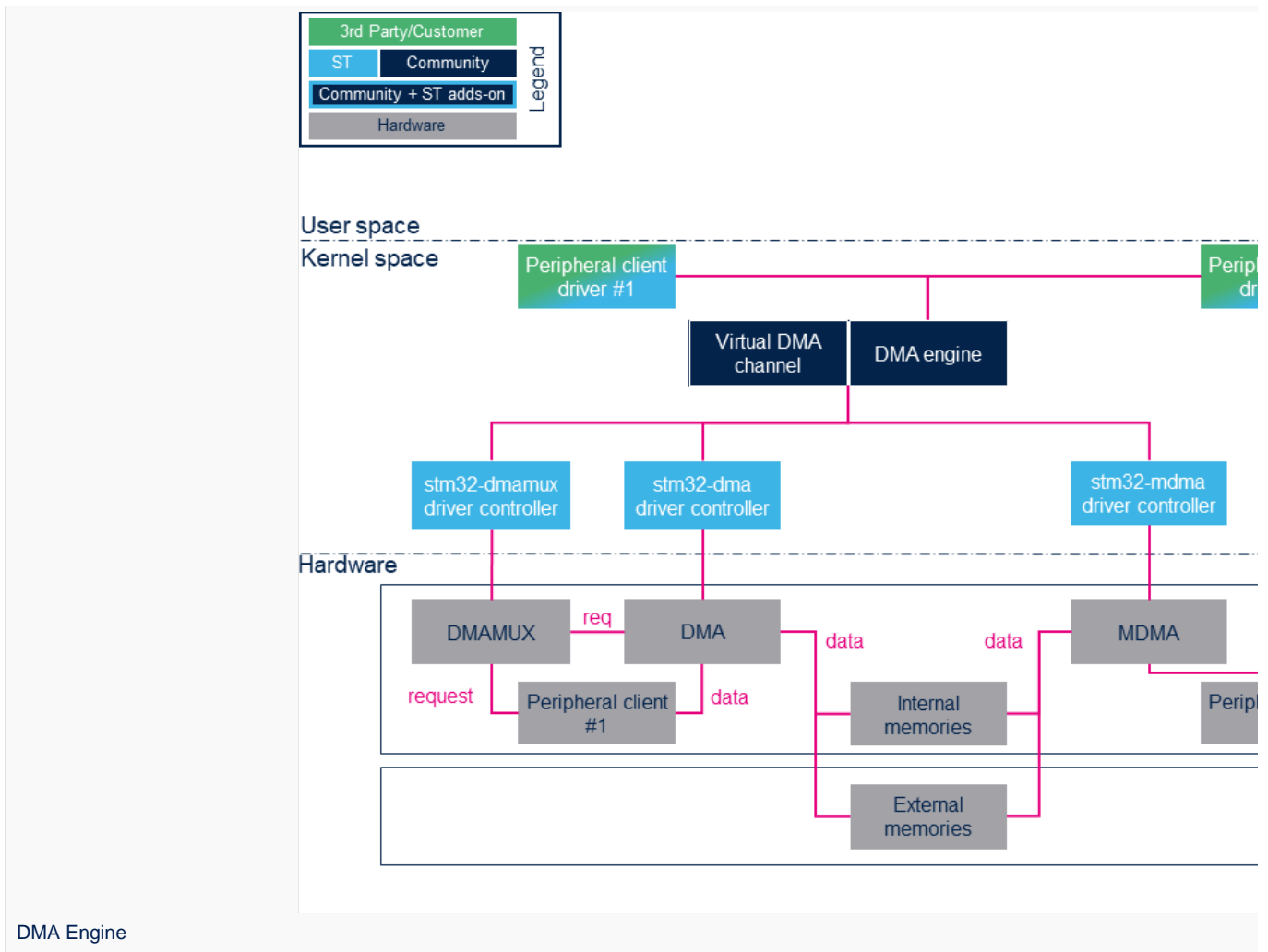
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This article provides basic information about the DMA framework. However it is worth browsing the Kernel documentation related to **DMA concept**<sup>[1]</sup>.

The direct memory access (DMA) is a feature that allows some hardware subsystems to access memory independently from the central processing unit (CPU).

The DMA can transfer data between peripherals and memory or between memory and memory.

## 2 System overview



### 2.1 Component description

- **Peripheral DMA client drivers:**

DMA clients are drivers that are mapped on the **DMA API**<sup>[2]</sup>.

- **DMA engine:**

The DMA engine is the engine core on which all clients rely.

Refer to **DMA provider**<sup>[1]</sup> for useful information on DMA internal behaviour.

- **Virtual DMA channel support:**

The virtual DMA channel support manages virtual DMA channels and DMA requests queues. This layer is no used by DMA clients.

- **STM32 xDMA driver:**



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The STM32 xDMA driver is used to develop the DMA engine API.

- **STM32 DMAMUX driver:**

The STM32 DMAMUX driver request multiplexer allows routing DMA request lines between the device peripherals and the DMA controllers.

- **DMAMUX, DMA and MDMA IP controller:**

This is the STM32 DMA controller that handles data transfers between peripherals and memories or memory and memory connected to the same bus.

DMAMUX (DMA request router): DMAMUX internal peripheral

DMA: DMA internal peripheral

MDMA : MDMA internal peripheral

- **Peripheral clients:**

Peripheral clients are peripherals where at least one DMA request line is mapped on DMAMUX.

- **Memories:**

Memories can be either internal (e.g. SRAM, RETRAM or BCKRAM) or external (DDR).

## 2.2 APIs description

Please refer to **DMA Engine API Guide**<sup>[3]</sup> for a clear description of the DMA framework API.

In addition, going through **Dynamic API**<sup>[4]</sup> provides insight on the DMA memory allocation API. The client has to rely on this API to properly allocate DMA buffers so that they are processed by the DMA engine without any trouble.

The document **Dynamic DMA mapping Guide**<sup>[5]</sup> can be read in conjunction with the previous one. It presents some examples and usecases.



## 3 Configuration

### 3.1 Kernel Configuration

The DMA engine and driver are enabled throughout menu config (see [Menuconfig](#) or how to configure kernel):

For DMA:

```
Device Drivers ->
[*] DMA Engine support ->
    [*] STMicroelectronics STM32 DMA support
```

For DMAMUX:

```
Device Drivers ->
[*] DMA Engine support ->
    [*] STMicroelectronics STM32 dma multiplexer support
```

For MDMA

```
Device Drivers ->
[*] DMA Engine support ->
    [*] STMicroelectronics STM32 master dma support
```

### 3.2 Device Tree configuration

The DT configuration can be done using the [STM32CubeMX](#).

Refer to the following articles for a description of the DT configuration:

- For DMA: [DMA device tree configuration](#)
- For DMAMUX: [DMAMUX device tree configuration](#)
- For MDMA: [MDMA device tree configuration](#)



## 4 How to trace and debug the framework

### 4.1 How to trace

Through menuconfig, enable DMA engine debugging and DMA engine verbose debugging (including STM32 drivers):

```
Device Drivers ->
  [*] DMA Engine support ->
    [*] DMA Engine debugging
    [*] DMA Engine verbose debugging (NEW)
```

### 4.2 How to debug

#### 4.2.1 devfs

**sysfs** entry can be used to browse for available DMA channels.

More information can be found in [sysfs](#).

The following command lists all the registered DMA channels:

```
Board $> ls /sys/class/dma/
dma0chan0 dma0chan13 dma0chan18 dma0chan22 dma0chan27 dma0chan31 dma0chan8
dma1chan3 dma2chan0 dma2chan5
dma0chan1 dma0chan14 dma0chan19 dma0chan23 dma0chan28 dma0chan4 dma0chan9
dma1chan4 dma2chan1 dma2chan6
dma0chan10 dma0chan15 dma0chan2 dma0chan24 dma0chan29 dma0chan5 dma1chan0
dma1chan5 dma2chan2 dma2chan7
dma0chan11 dma0chan16 dma0chan20 dma0chan25 dma0chan3 dma0chan6 dma1chan1
dma1chan6 dma2chan3
dma0chan12 dma0chan17 dma0chan21 dma0chan26 dma0chan30 dma0chan7 dma1chan2
dma1chan7 dma2chan4
```

Each channel is expanded as follows:

```
Board $> ls -la /sys/class/dma/dma0chan0/
total 0
drwxr-xr-x 3 root root 0 Jun 7 21:22 .
drwxr-xr-x 34 root root 0 Jun 7 21:22 ..
-r--r--r-- 1 root root 4096 Jun 9 13:11 bytes_transferred
lrwxrwxrwx 1 root root 0 Jun 9 13:11 device -> ../../../../58000000.dma
-r--r--r-- 1 root root 4096 Jun 9 13:11 in_use
-r--r--r-- 1 root root 4096 Jun 9 13:11 memcpy_count
drwxr-xr-x 2 root root 0 Jun 9 13:11 power
lrwxrwxrwx 1 root root 0 Jun 9 13:11 subsystem -> ../../../../class/dma
-rw-r--r-- 1 root root 4096 Jun 7 21:22 uevent
```

**device** indicates which DMA driver manages the channel.

echoing **in\_use** indicates whether the channel has been allocated or not.





```
Board $> cat /sys/class/dma/dma0chan0  
/in_use  
1
```

#### 4.2.2 Debugfs

debugfs entries are available. They are documented in *Part III - Debug drivers use of the DMA-API*<sup>[4]</sup>.

#### 4.2.3 dmatest

dmatest can be used to validate or debug DMA engine and driver without using client devices. This module is more a test than a debug module. It performs a memory-to-memory copy using standard DMA engine API.

For details on how to use this kernel module, refer to <sup>[6]</sup>.



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## 5 Source code location

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DMA: `drivers/dma/stm32-dma.c`

MDMA: `drivers/dma/stm32-mdma.c`

DMAMUX: `drivers/dma/stm32-dmamux.c`

DMA engine:

- Engine: `drivers/dma/dmaengine.c`
- Virtual channel support: `drivers/dma/virt-dma.c`



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## 6 To go further

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Very useful documentation can be found at <https://www.kernel.org/doc/html/v5.4/driver-api/dmaengine/index.html>.



## 7 References

- 1.01.1 DMA provider
- DMA API
- DMA Engine API Guide
- 4.04.1 Documentation/DMA-API.txt Dynamic DMA mapping using the generic device
- Documentation/DMA-API-HOWTO.txt Dynamic DMA mapping Guide
- driver-api/dmaengine/dmatest.html

Direct Memory Access

Central processing unit

Application programming interface

Doubledata rate (memory domain)

Device Tree

Device File System (See [https://en.wikipedia.org/wiki/Device\\_file#DEVFS](https://en.wikipedia.org/wiki/Device_file#DEVFS) for more details)

System File System (See <https://en.wikipedia.org/wiki/Sysfs> for more details)

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