IP_CAM Ethernet Application using STM32F2xx

STMicroelectronics

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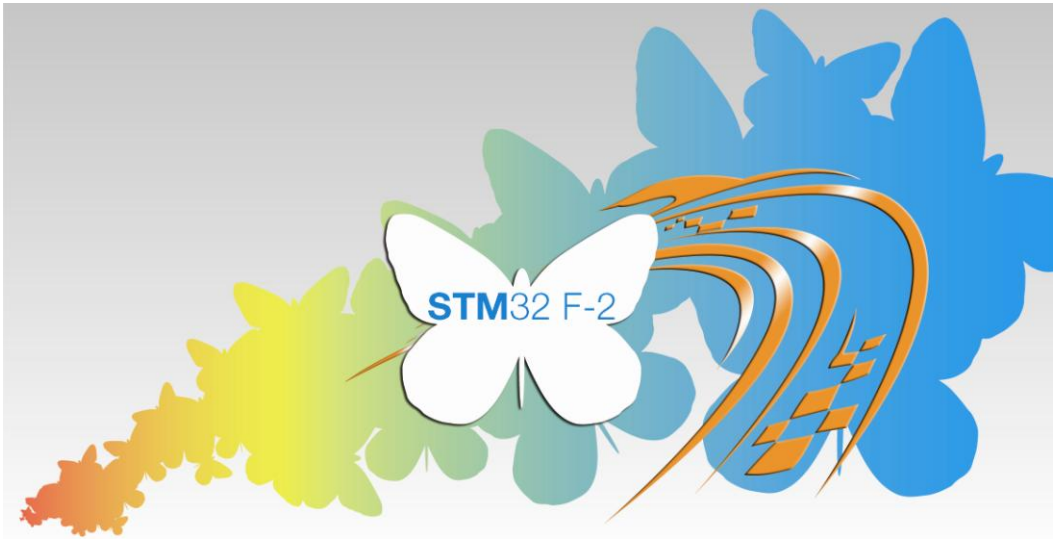

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- Basic Ethernet
- STM32F2: Architecture, Features & Roadmap
- STM32F2xx Peripherals: Ethernet-Block & DCMI Block
- Demo-Board (STM3220G-EVAL)
- S/W : Basic lwIP (Intro & porting tips, server p/g)

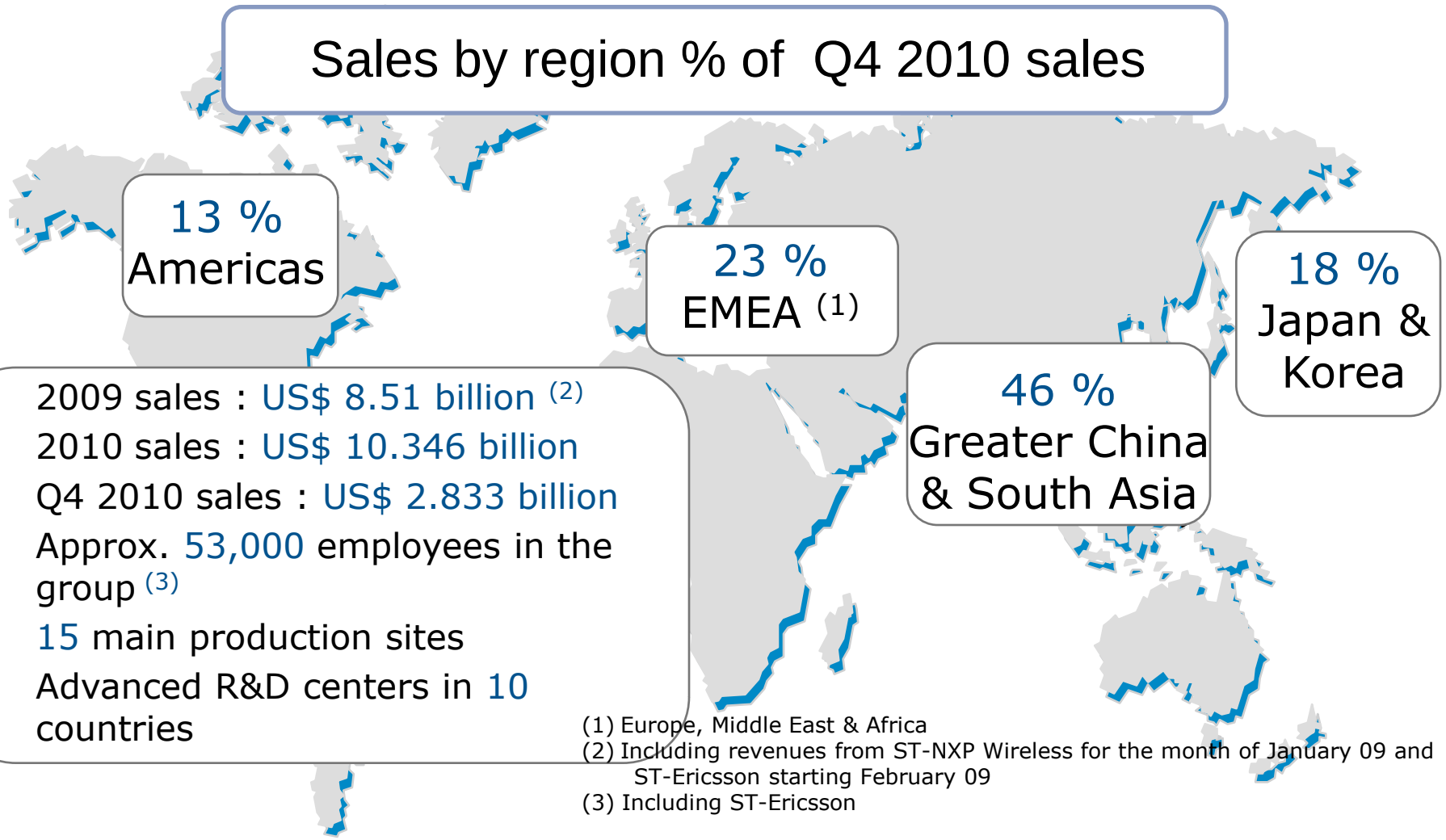
  Basic Socket p/g(Server, Client)

  Custom-protocol for IP_CAM-example
- Demo: IP-CAM

About STMicroelectronics

A Global Semiconductor Company

Sales by region % of Q4 2010 sales

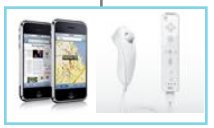
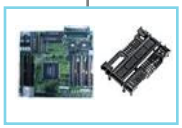


- 2009 sales : US$ 8.51 billion (2)
- 2010 sales : US$ 10.346 billion
- Q4 2010 sales : US$ 2.833 billion
- Approx. 53,000 employees in the group (3)
- 15 main production sites
- Advanced R&D centers in 10 countries

(1) Europe, Middle East & Africa
(2) Including revenues from ST-NXP Wireless for the month of January 09 and ST-Ericsson starting February 09
(3) Including ST-Ericsson

Business Segments

ST ERICSSON
50/50 JV with Ericsson

	Wireless	Consumer, Computer and Communication Infrastructure			Industrial and Multisegment Sector ("IMS")	
Major Product Lines		Home Entertainment & Displays	Computer & Communication Infrastructure	Automotive Products Group	Analog, Power and MEMS	Microcontrollers, Memories and Secure MCUs
Products						
Major Customers						

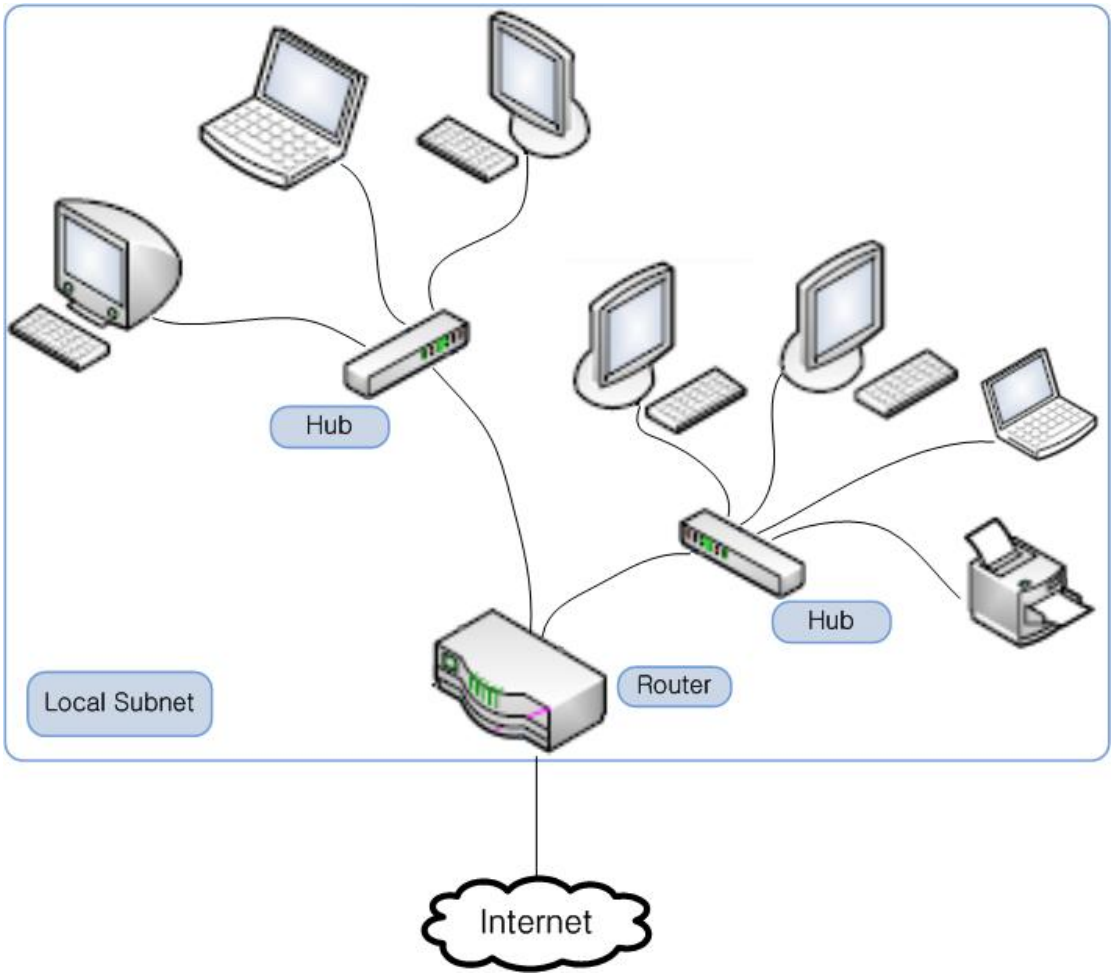
What's Ethernet? Why we use it?

- Easy to use/access around us.
- Open Standard
- Many Protocols are ready.
- Easy to convert to Wireless Application.
- → Same standard spec.
- Just replace MAC & PHY to implement WIFI

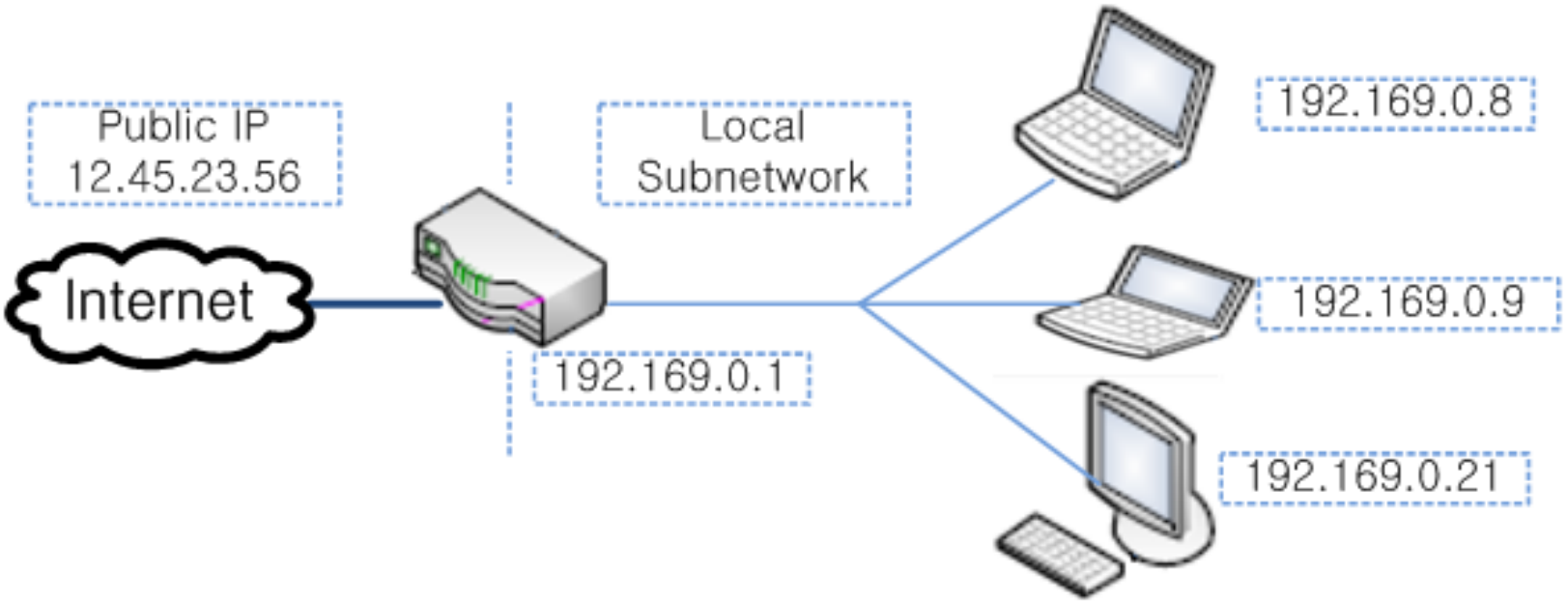
Ethernet Applications

- Industrial Control/Monitoring or Factory Automation
- Building Management System
- Security System.
- Info-Desk (Book-store, Public Area)
- Payment System
- Home-Automation/Monitoring
- Remote Data Logging

LAN



LAN


Public IP
12.45.23.56
Local
Subnetwork
Internet
192.169.0.1
192.169.0.8
192.169.0.9
192.169.0.21

TCP vs UDP

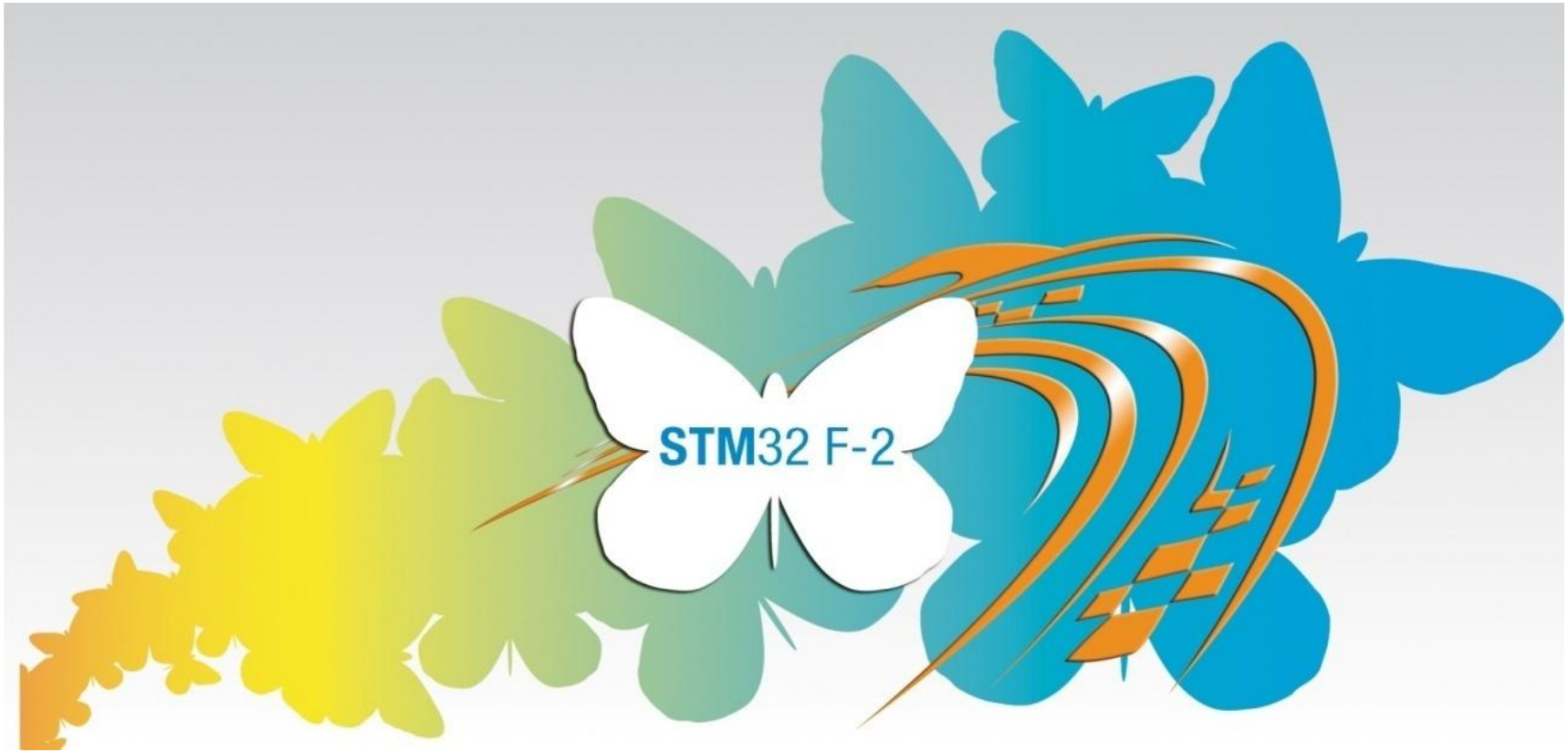
TCP	vs	UDP
- 양방향 확인형 Protocol (전송 & ACK처리) -Sequence Numbering -If Timeout -> Resend! -Reliable(Trustable)! -Overhead : Higher -No Time-Critical Application		- 전송에만 중점을 둔 Protocol (No ACK) - Packet은 보장받지 못함. - 주기적인 데이터 전송. - OverHead : Lower - Real-Time Application

MAC Address

- Globally Unique Network Device Address(6 bytes)
- → H/W device Address or Physical Address
- → 1st 3 byte : Vendor ID
- Defined by IEEE-802.3
- Lease Fee : us$550/4096, us$1650/16M (not accurate)

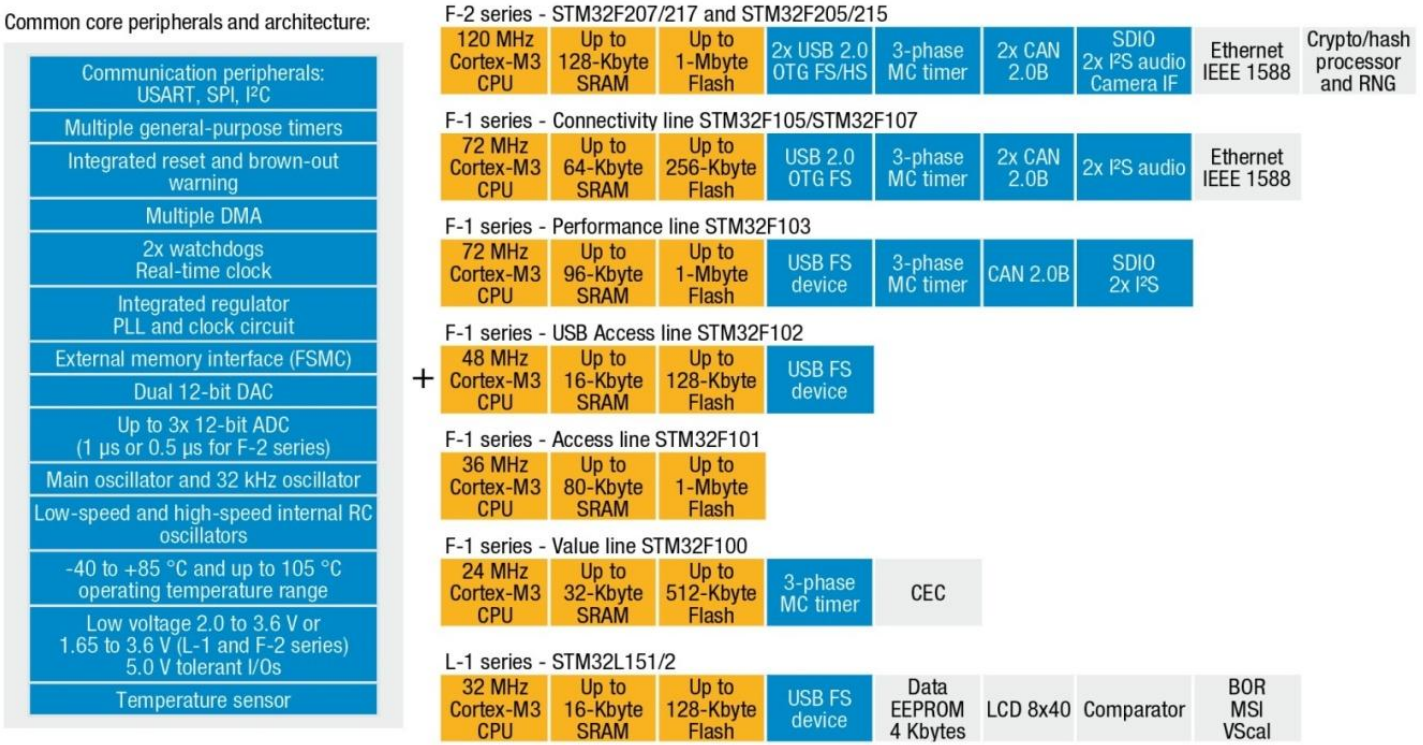
STM32 F-2 series

High-performance Cortex-M3 MCUs



STMicroelectronics leadership

- ST is the undisputed leader for ARM Cortex-M MCUs
  - STM32 represented greater than 50% of Cortex-M based MCU shipments in H1 2010
- With 7 product lines and over 180 part numbers, STM32 is the broadest Cortex-M portfolio in the market



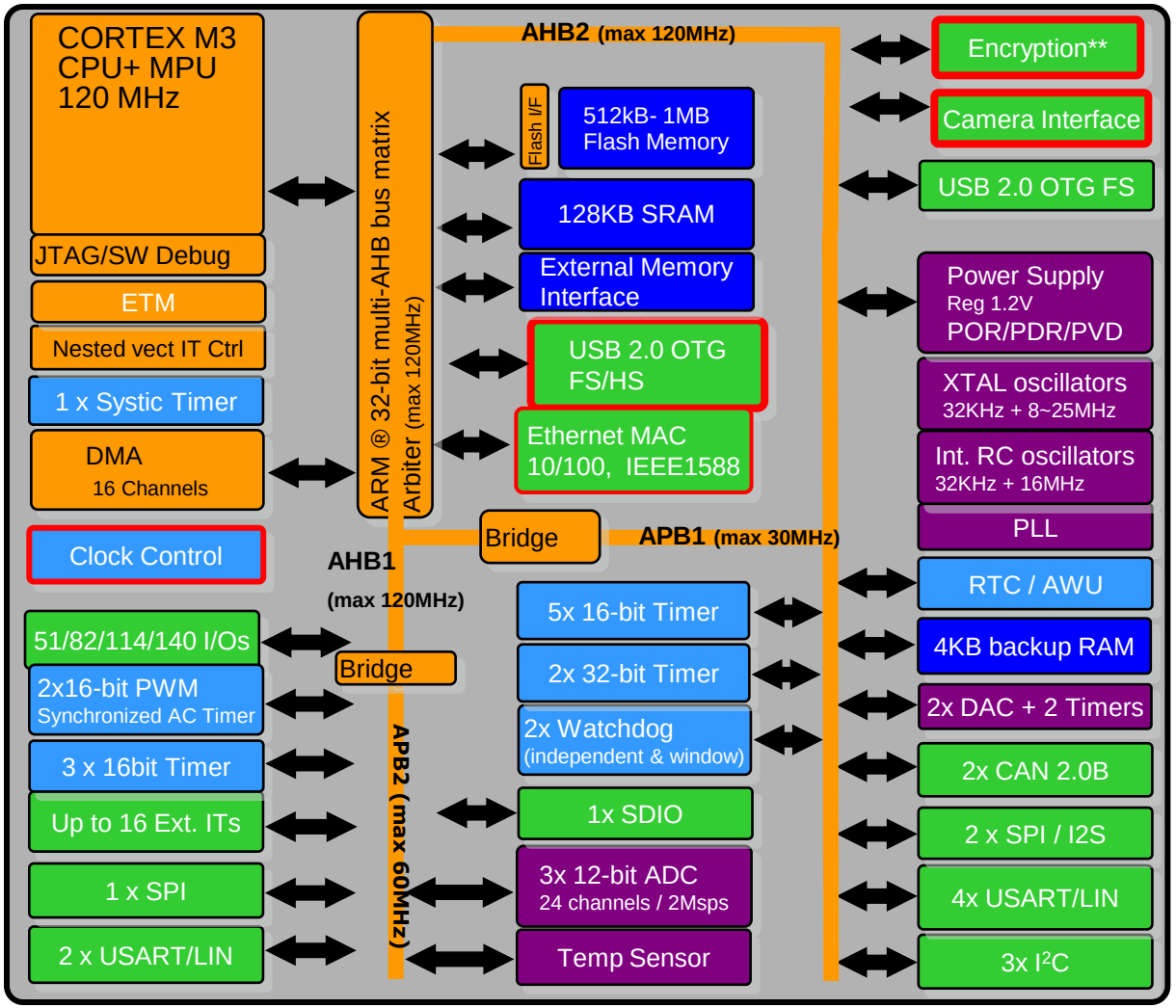
STM32 F-2 series: key benefits

Real-time performance	Outstanding power efficiency	Superior and innovative peripherals	Maximum integration	Extensive tools and software
+ ART Accelerator, Multi-AHB bus matrix, Excellent real-time 120 MHz/ 150 DMIPS at zero-wait state execution performance from Flash	<1 µA V_{BAT} with RTC, ultra-low dynamic power consumption 1.65 to 3.6 V V_{DD}	USB-OTG High speed, camera interface, Ethernet, CAN, crypto/ hash processor, external memory interface	1-Mbyte Flash, 128-Kbyte SRAM, 528 OTP bytes, 4-Kbyte backup SRAM, reset circuitry, voltage regulator, 1% RC oscillator, PLL	Various IDE starter kits, libraries, RTOS and stacks
Future proof design	**Environment friendly, suits low-power operation**	**Address all your needs and beyond**	**Cost and space saving**	**More time for innovation**

STM32 F-2 series, over 30 part numbers, a new addition to the STM32 platform now counting over 180 compatible devices

STM32F2xx Block Diagram

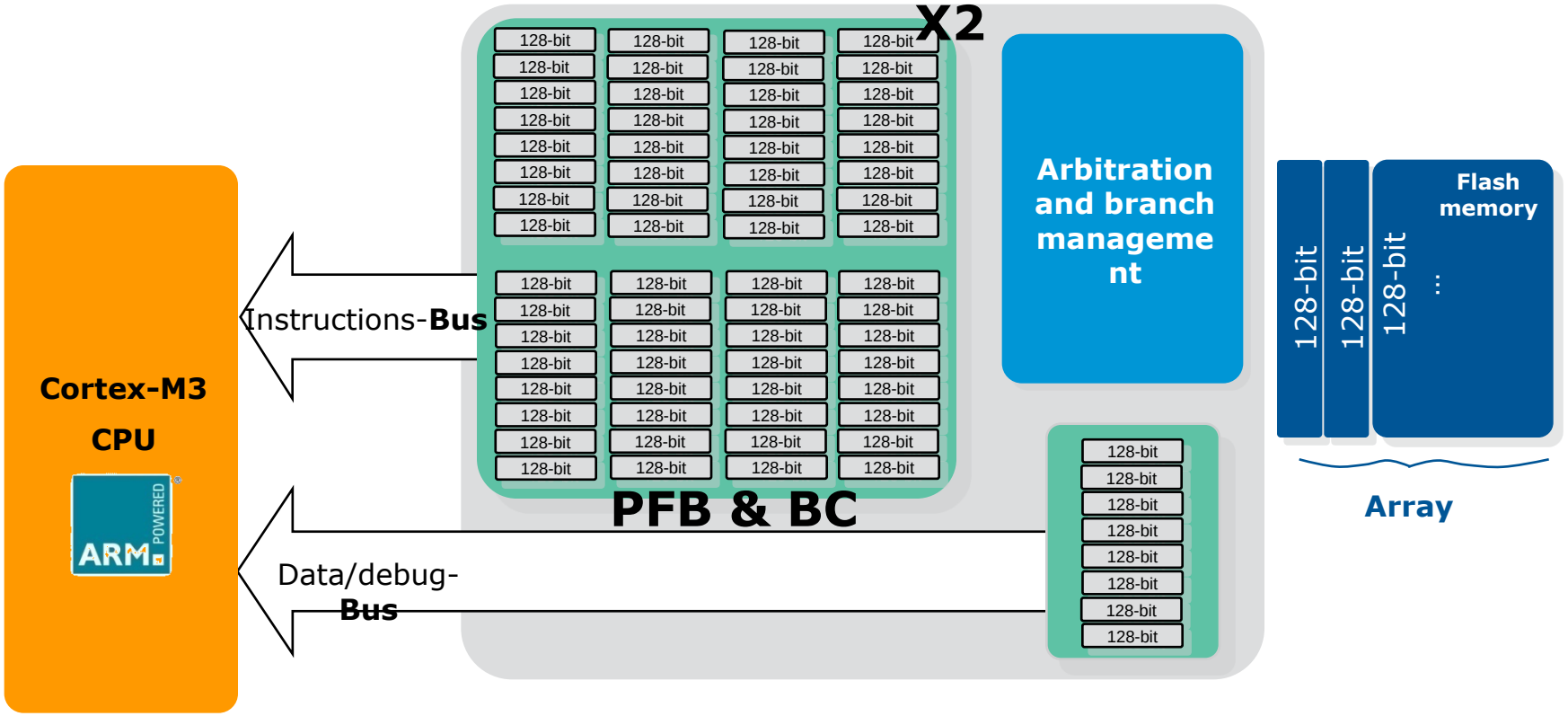
- **Cortex-M3 w/ MPU and ETM**
- **Memory**
  - Up to 1MB Flash memory
  - 128KB RAM
  - FSMC up to 60MHz
- **New application specific peripherals**
  - USB OTG HS w/ ULPI interface
  - Camera interface
  - HW Encryption**: DES, 3DES, AES 256-bit, SHA-1 hash, RNG.
- **Enhanced peripherals**
  - USB OTG Full speed
  - ADC: 0.5µs conversion/2Msps, up to 6Msps in interleaved triple mode
  - ADC/DAC working down to 1.8V
  - Dedicated PLL for I2S precision
  - Ethernet w/ HW IEEE1588 v2.0
  - 32-bit RTC with calendar
  - 4KB backup SRAM in VBAT domain
  - Pure 1% RC
  - 2 x 32bit and 8 x 16bit Timers
  - high speed USART up to 7.5Mb/s
  - high speed SPI up to 30Mb/s
- **RDP (JTAG fuse)**
- **More I/Os in UFBGA 176 package**



Real-time performance

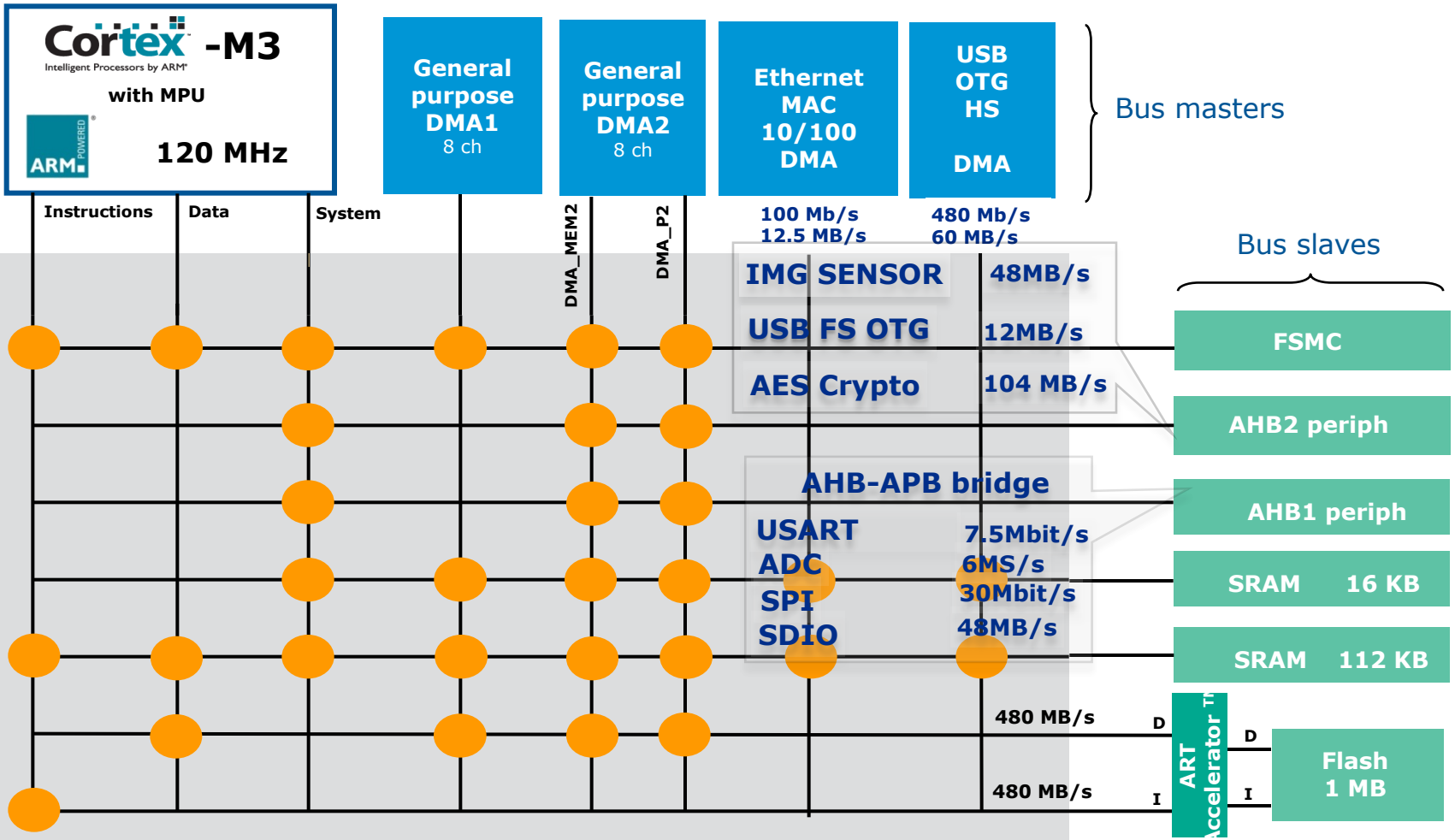
ART Accelerator™

- The adaptive real-time memory accelerator unleashes the Cortex-M3 core's maximum processing performance equivalent to 0-wait state execution Flash up to 120 MHz.

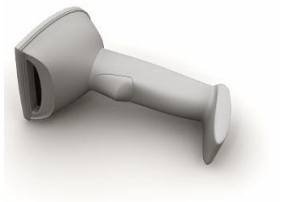


Real-time performance

32-bit multi-AHB bus matrix



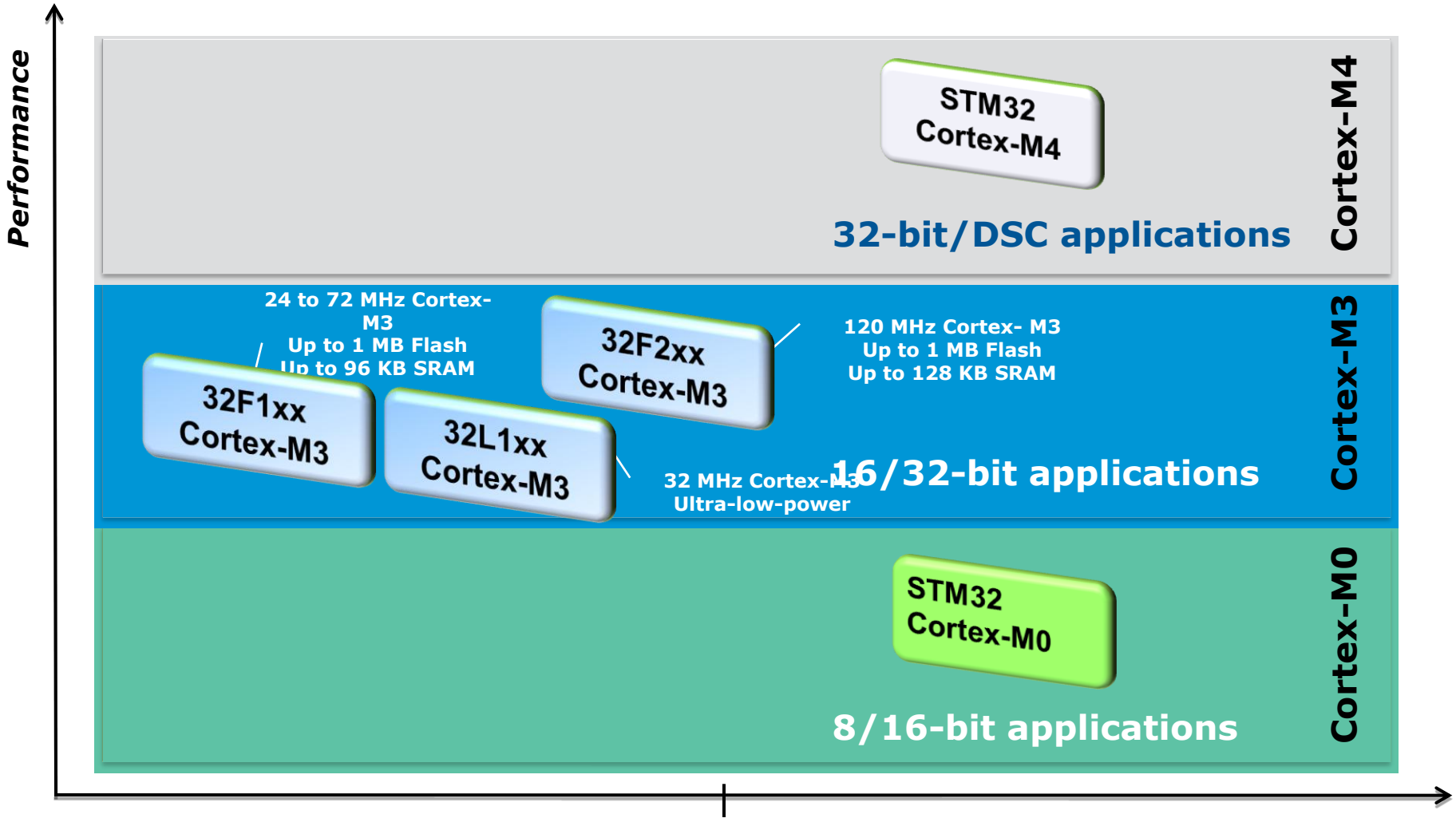
STM32 F-2 Series Applications Served



- **Point of Sale/Inventory Management**
  - Cash Registers and Terminals
  - Portable Collection Terminals
  - Package Tracking
  - Thermal Printers
  - Vending: Fuel, Drinks, Snacks, Tickets
- **Industrial Automation**
  - Low-End/Mid PLC
  - Distributed Control
  - Machine Vision
  - Industrial Networking
  - Robotics
- **Transportation**
  - Fleet Management
  - Vehicle Data Recorder
- **Medical**
  - Patient Monitors
  - Fitness Machines

- Building Security/Fire/HVAC
  - Alarm Control Panel
  - Time & Attendance
  - Voice recognition/synthesis
  - Biometric Identification
  - Surveillance and Camera
- Test & Measurement
  - Data Acquisition
  - Portable Test Equipment
  - Automotive Diagnostic Equipm
- Consumer
  - Car audio/home audio (mp3 players)
  - Electronic Toys
  - Aftermarket Automotive GPS
  - Fish-Finders
- Communication
  - Serial Protocol Gateways
  - Office Phones

Global STM32 Roadmap

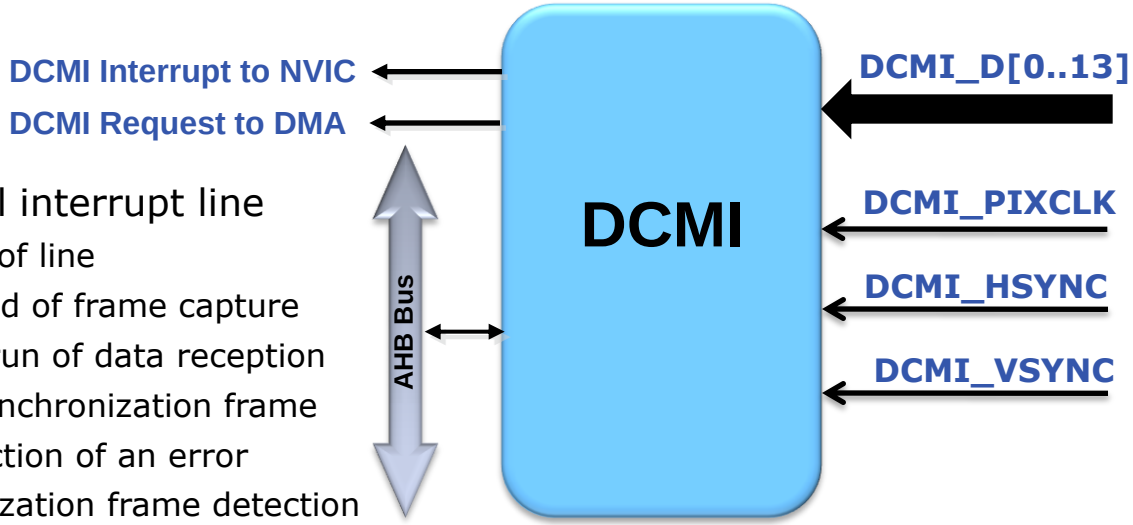


DCMI Features

- The Digital Camera Interface has the following main features:
  - 8-, 10-, 12- or 14-bit parallel interface
  - Continuous or snapshot mode
  - Crop feature
  - Supports the following data-transfer formats:
    - 8/10/12/14- bit progressive scan: either monochrome or raw bayer
    - YCbCr 4:2:2 progressive scan
    - RGB 565 progressive video
    - Compressed data: JPEG
- With a 48MHz PIXCLK and 8-bit parallel input data interface it is possible to receive:
  - up to 15fps uncompressed data stream in SXGA resolution (1280x1024) with 16-bit per pixel
  - up to 30fps uncompressed data stream in VGA resolution (640x480) with 16-bit per pixel

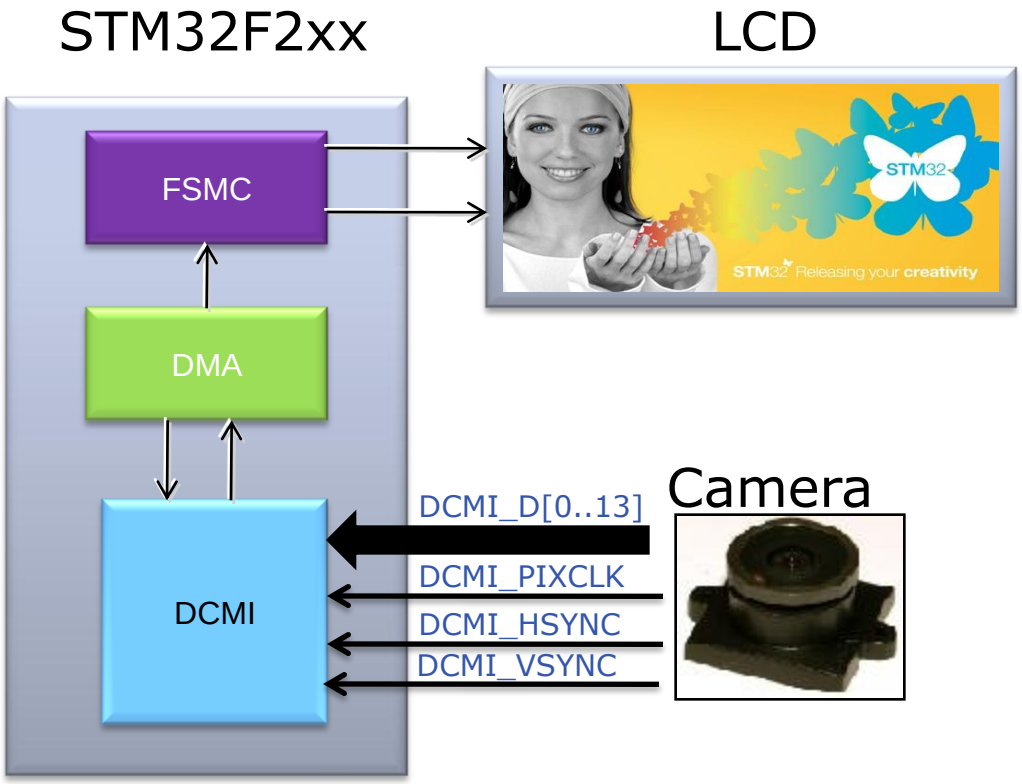
DCMI Block Diagram

- The digital camera interface is a synchronous parallel interface that can receive data flows, It consists of:
  - up to 14 data lines DCMI_D[0..13]
  - Pixel clock line DCMI_PIXCLK with a programmable polarity, rising/falling edge.
  - The maximum AHB/PIXCLK ratio =2.5 (PIXCLK=48MHz max)
  - Horizontal synchronization DCMI_HSYNC, indicates the start/end of a line
  - Vertical synchronization DCMI_VSYNC, indicates the start/end of a frame



- Five interrupts flags, 1 global interrupt line
  - IT_LINE Indicates the end of line
  - IT_FRAME Indicates the end of frame capture
  - IT_OVR indicates the overrun of data reception
  - IT_VSYNC Indicates the synchronization frame
  - IT_ERR Indicates the detection of an error in the embedded synchronization frame detection

DCMI Data transfer



- The data are packed into a 32-bit data register (DCMI_DR) connected to the AHB bus
- 4x32-bit FIFO with DMA handling.

DCMI Extended data mode

- The camera interface can capture 14-bit, 12-bit, 10-bit or 8-bit data
- If less than 14 bits are used, the unused input pins must be connected to ground.

8-Bit

Byte address	31:24	23:16	15:8	7:0
0	Dn+3[7:0]	Dn+2[7:0]	Dn+1[7:0]	Dn[7:0]
4	Dn+7[7:0]	Dn+6[7:0]	Dn+5[7:0]	Dn+4[7:0]

10-Bit

Byte address	31:26	25:16	15:10	9:0
0	0	Dn+1[9:0]	0	Dn[9:0]
4	0	Dn+3[9:0]	0	Dn+2[9:0]

12-Bit

Byte address	31:28	27:16	15:12	11:0
0	0	Dn+1[11:0]	0	Dn[11:0]
4	0	Dn+3[11:0]	0	Dn+2[11:0]

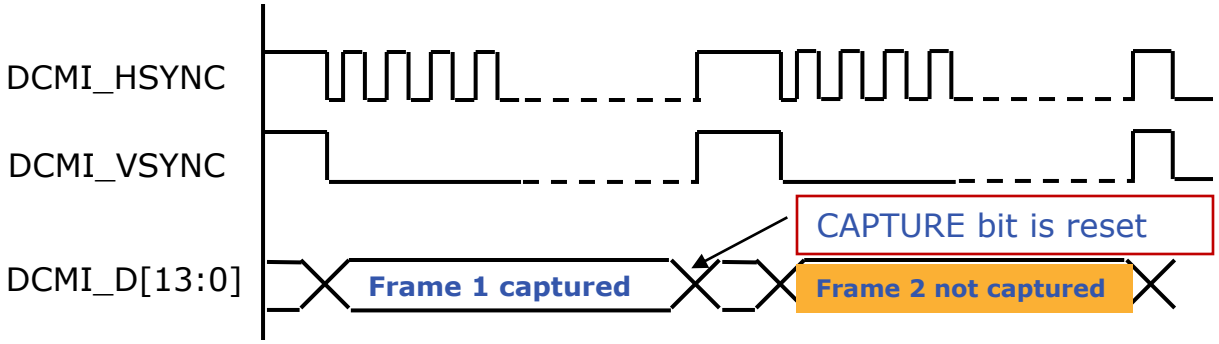
14-Bit

Byte address	31:30	29:16	15:14	13:0
0	0	Dn+1[13:0]	0	Dn[13:0]
4	0	Dn+3[13:0]	0	Dn+2[13:0]

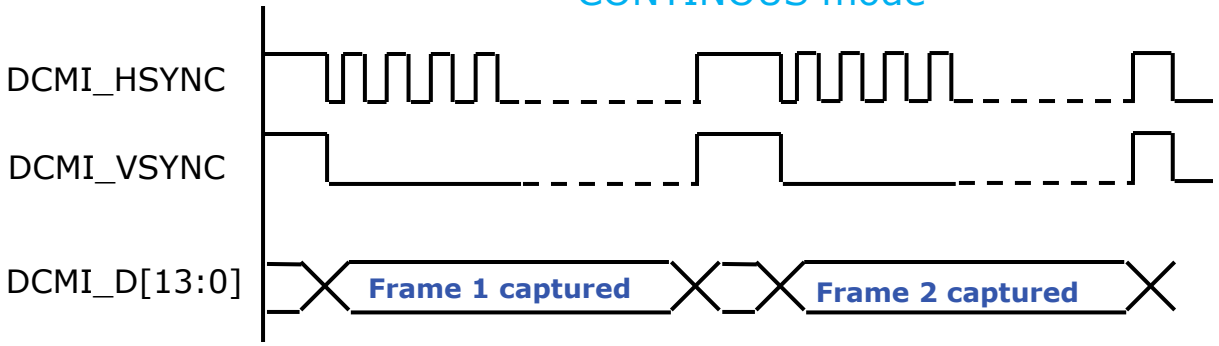
DCMI Capture mode

- The DCMI interface supports two types of capture:
  - Snapshot (single frame)
  - Continuous grab.

SNAPSHOT mode

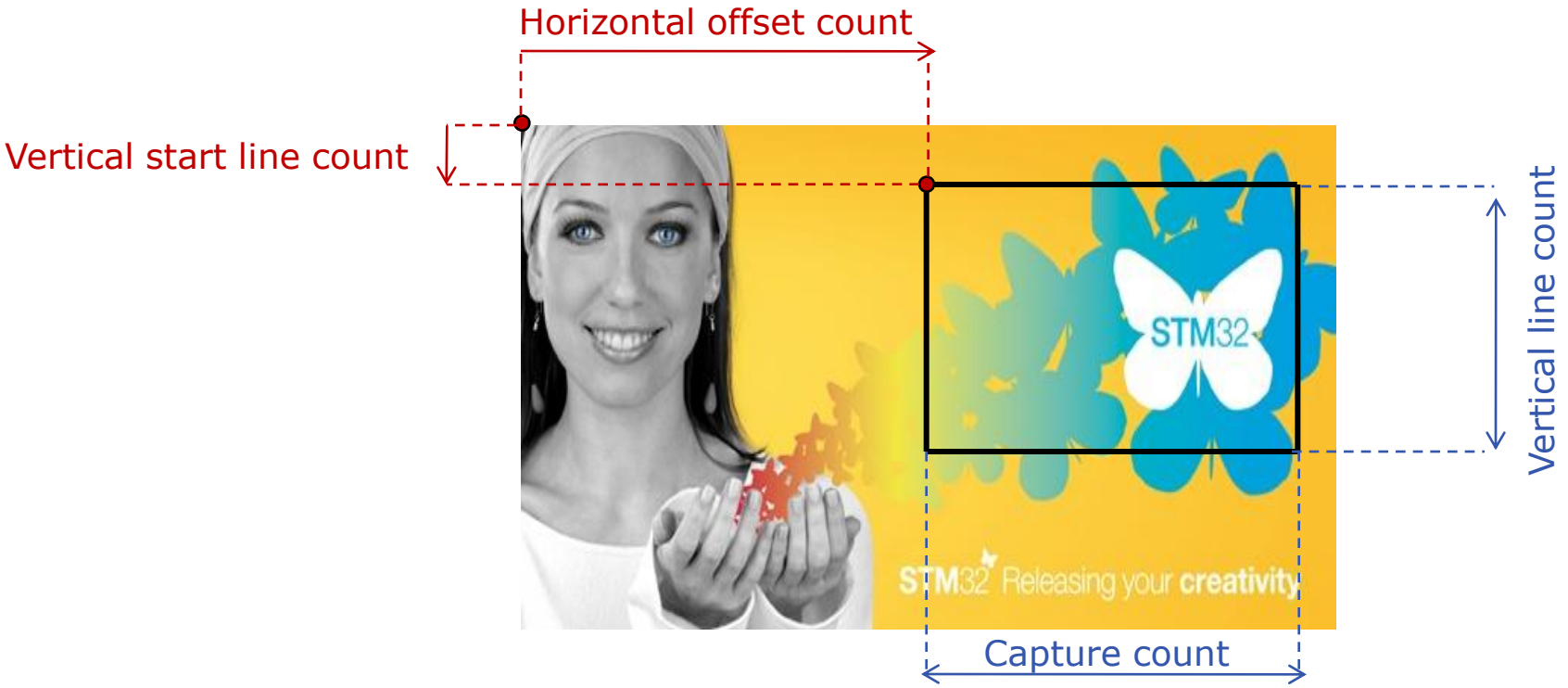


CONTINOUS mode



DCMI CROP feature

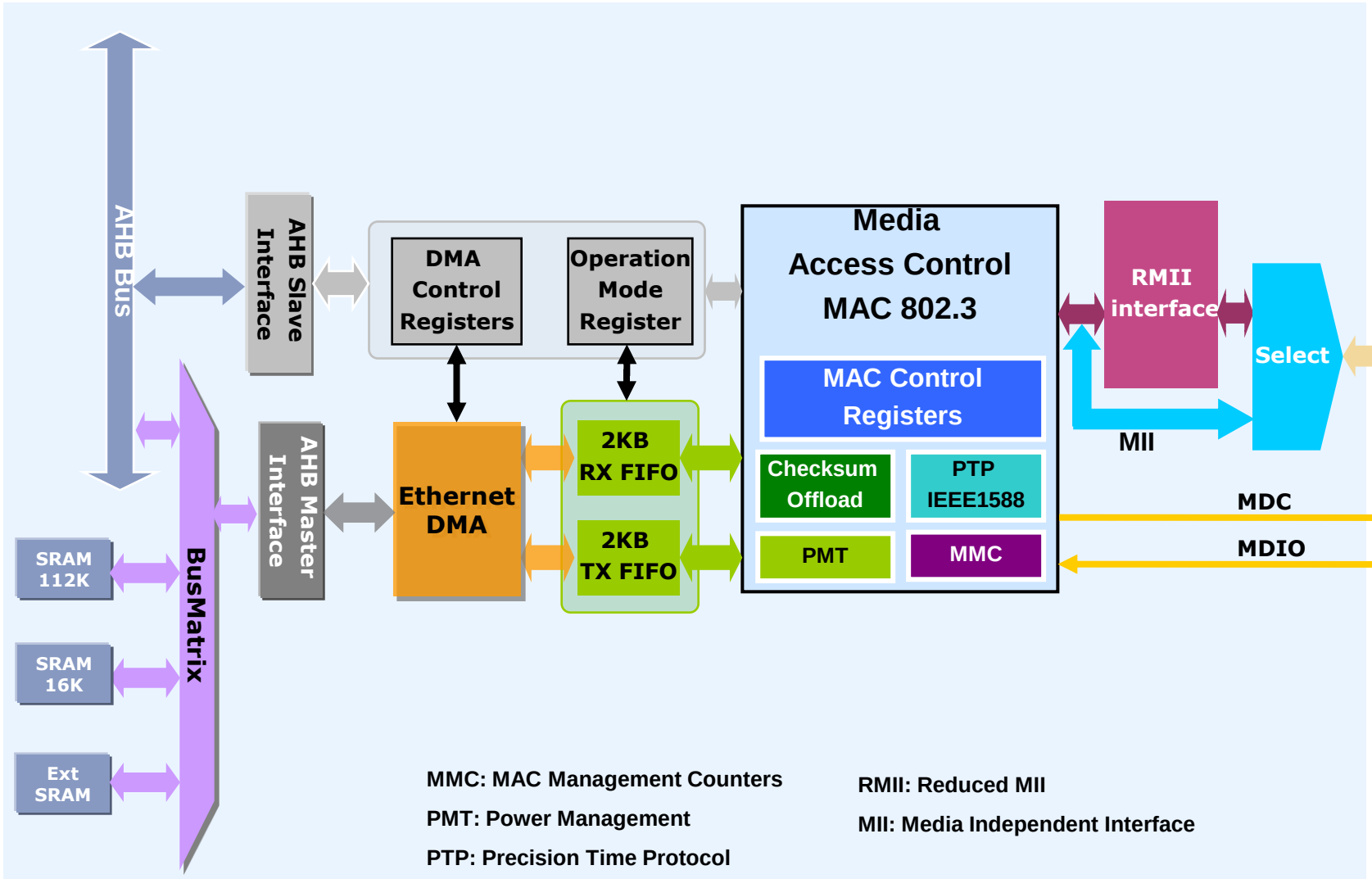
- The DCMI interface supports two types of capture:
- The DCMI can select a rectangular window from the received image
- The start coordinates and size are specified using two 32-bit registers DCMI_CWSTRT and DCMI_CWSIZE.
- The size of the window is specified in number of pixel clocks (horizontal dimension) and in number of lines (vertical dimension)



Ethernet MAC 10/100 Main Features

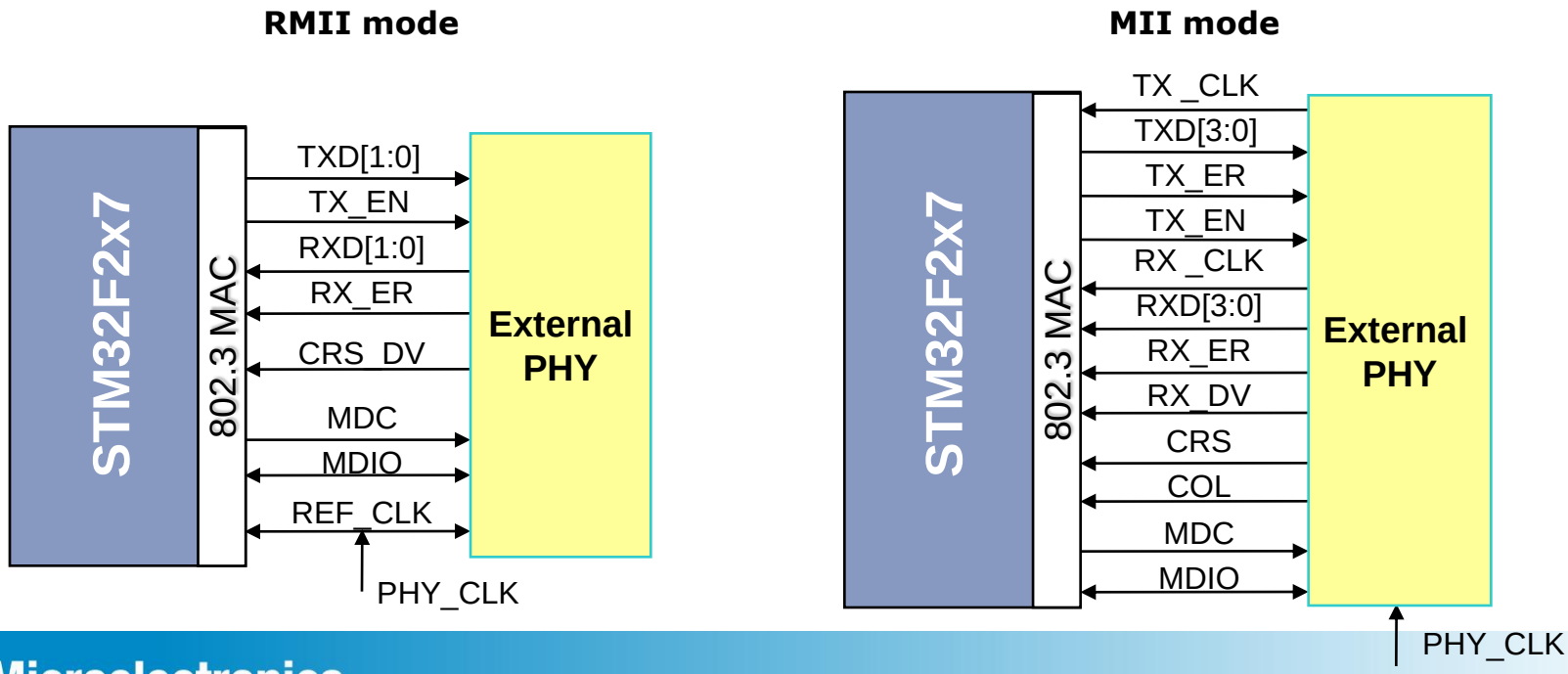
- Supports 10/100Mbits Half/Full-duplex operations modes
- MII/RMII PHY interface
- Several options for MAC address filtering
- IPv4 checksum offload during receive and transmit operation
- Dedicated DMA controller with two FIFOs (Rx/Tx) of 2KBytes each
  - Connected as AHB master to system bus matrix
- Ethernet Time Stamping support - IEEE1588 version 2
- Power management: Wake on LAN with Magic Packet or Wakeup frame
- MAC management Counters for statistics
- MII loopback mode for debug purpose

Ethernet Block Diagram



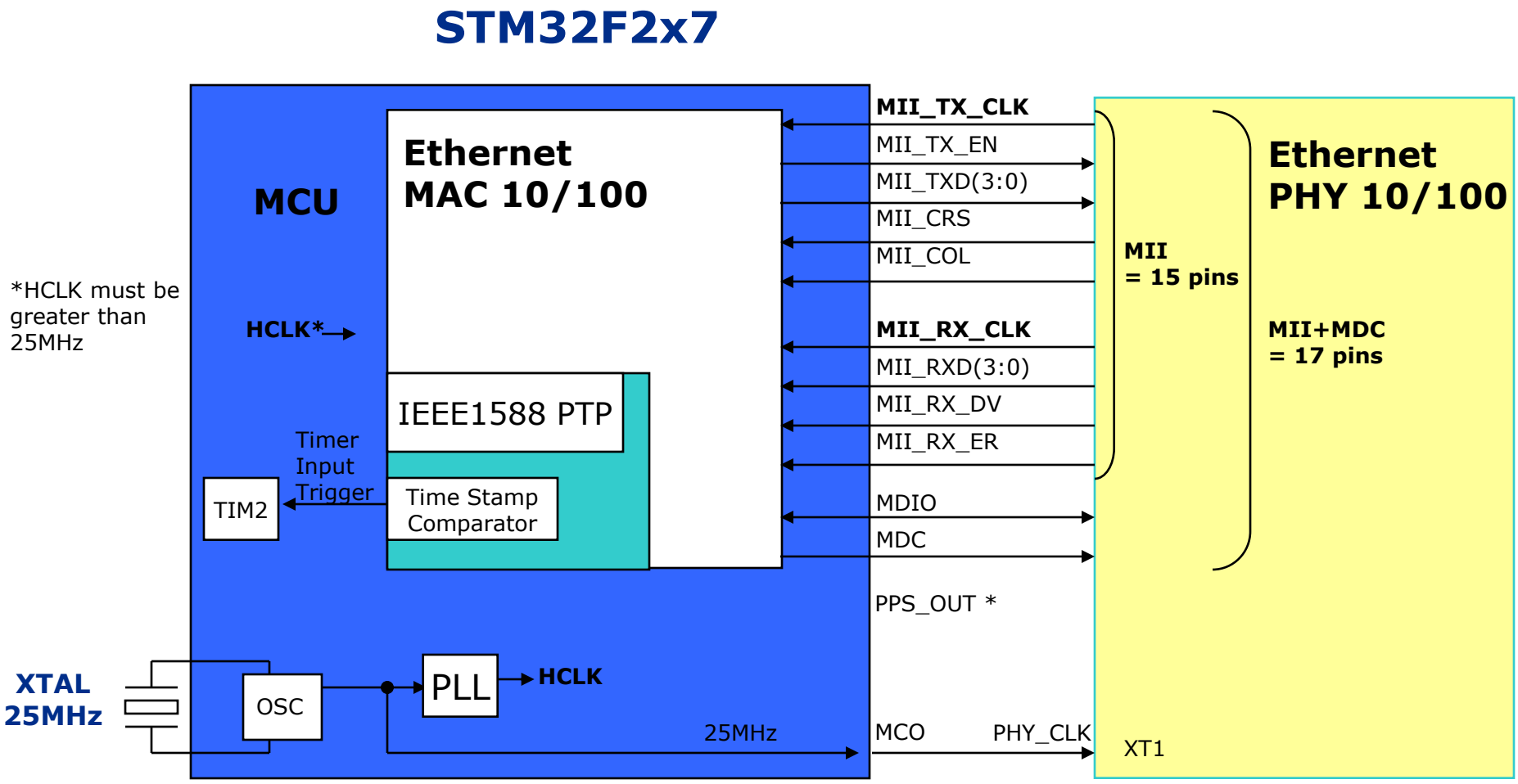
Physical Layer Interface

- Supports both Media Independent Interface (MII) and Reduced Media Independent Interface (RMII)
- RMII is a lower pin count alternative, which targets multi-port applications and low cost design
  - MII = 16 pins (8 data and 8 control)
  - RMII = 7 pins (4 data and 3 control)



Ethernet Interface Solution (1/4)

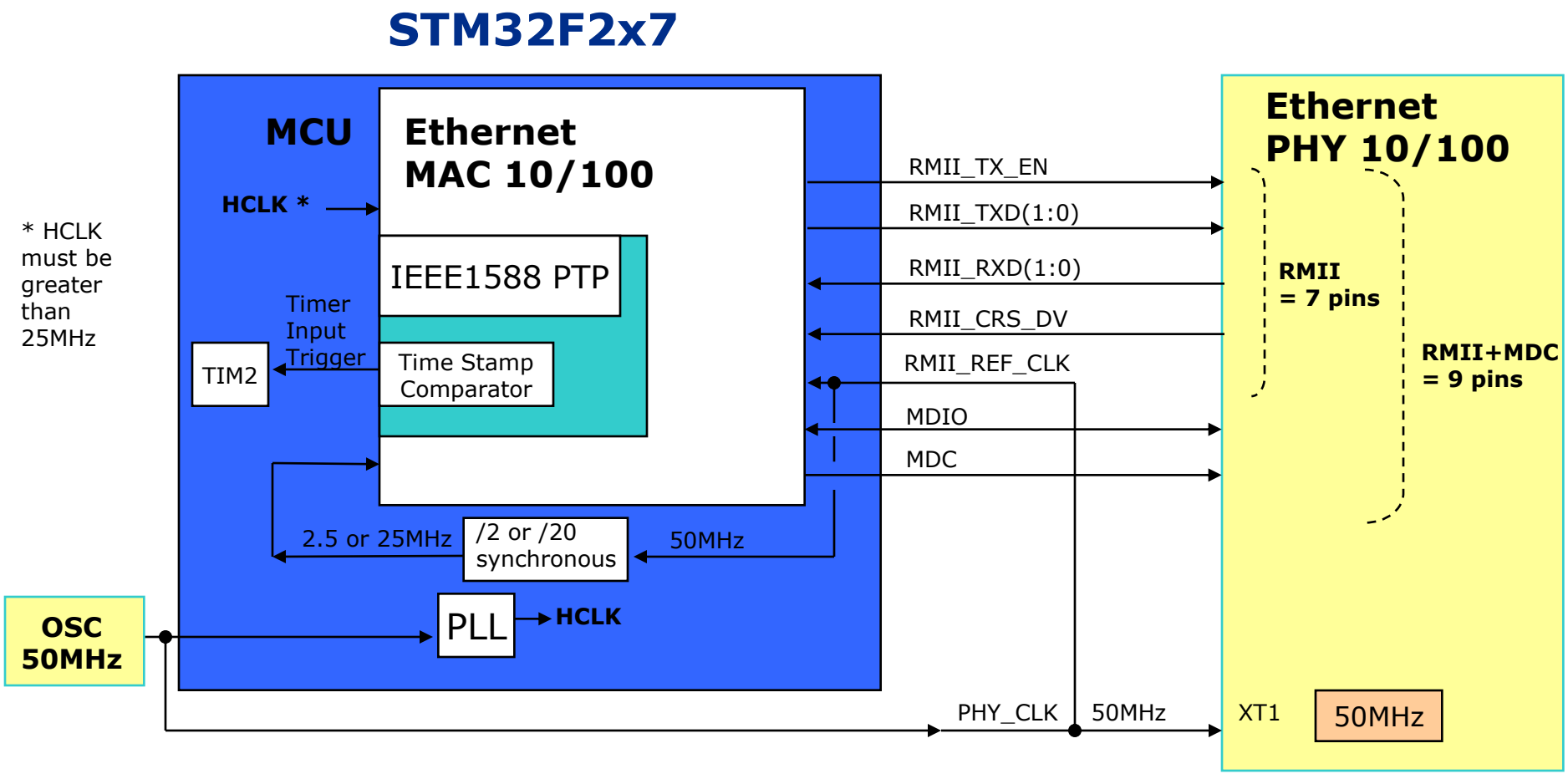
- MII mode using one 25MHz crystal



* Pulse Per Second when using IEEE1588 PTP, Optional Signal

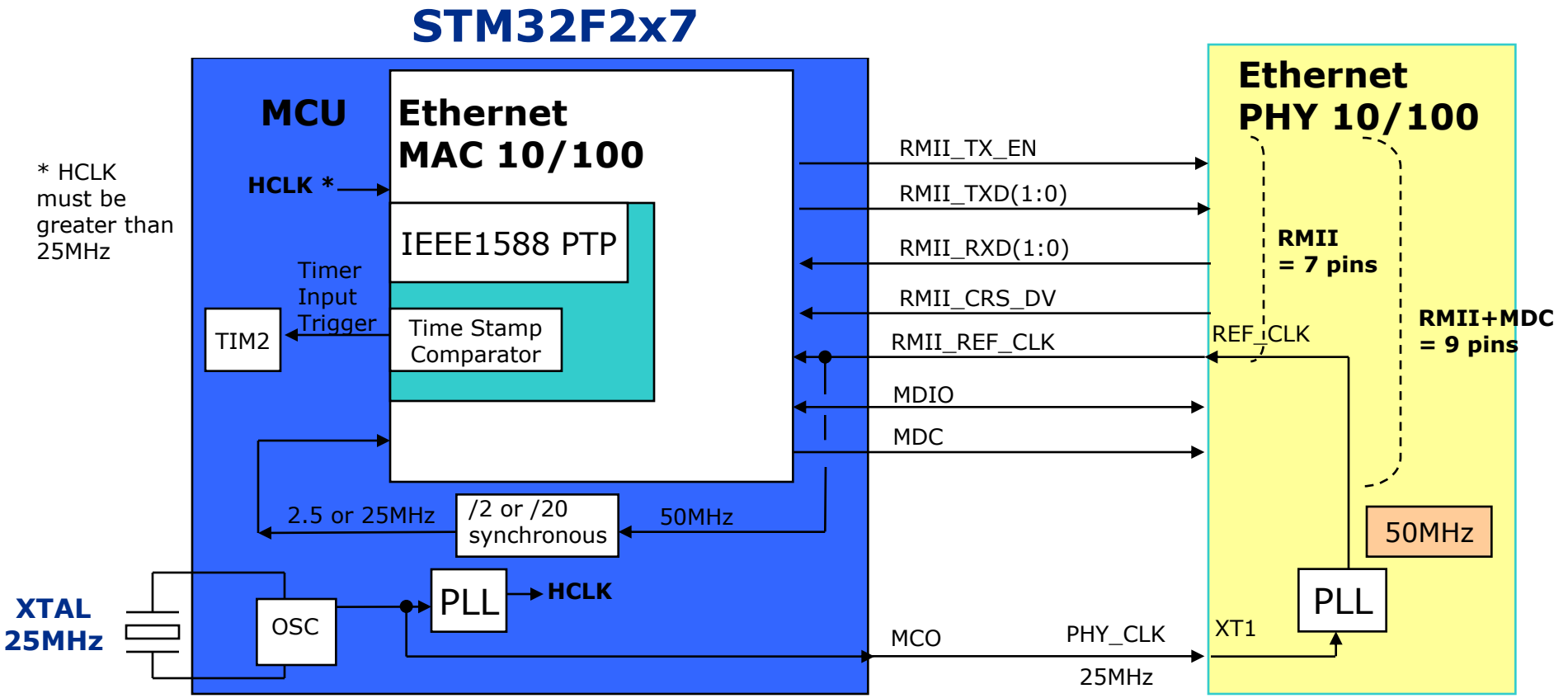
Ethernet Interface Solution (2/4)

- RMII with one 50MHz oscillator



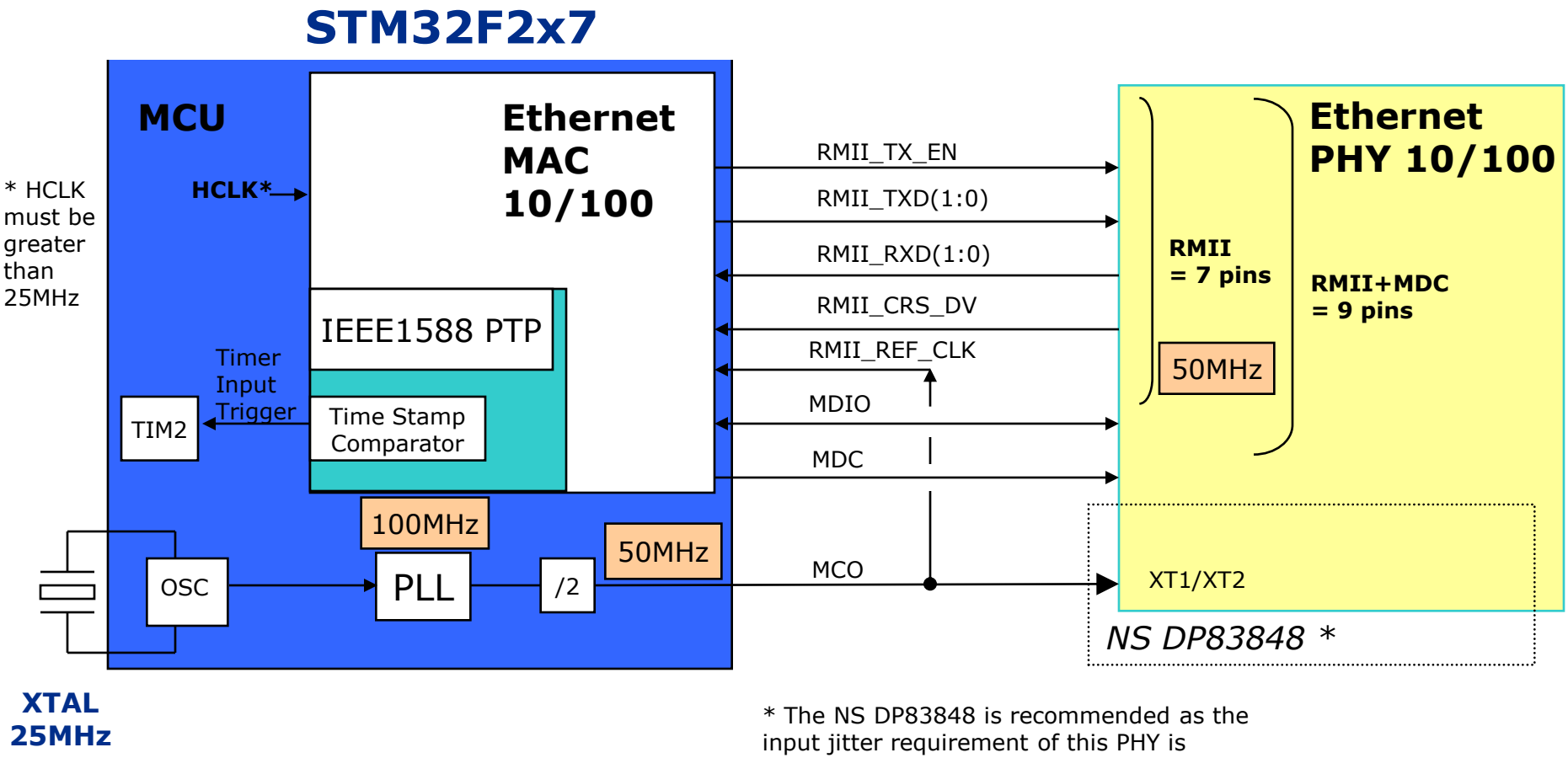
Ethernet Interface Solution (3/4)

- RMII with one 25MHz crystal and PHY with PLL



Ethernet Interface Solution (4/4)

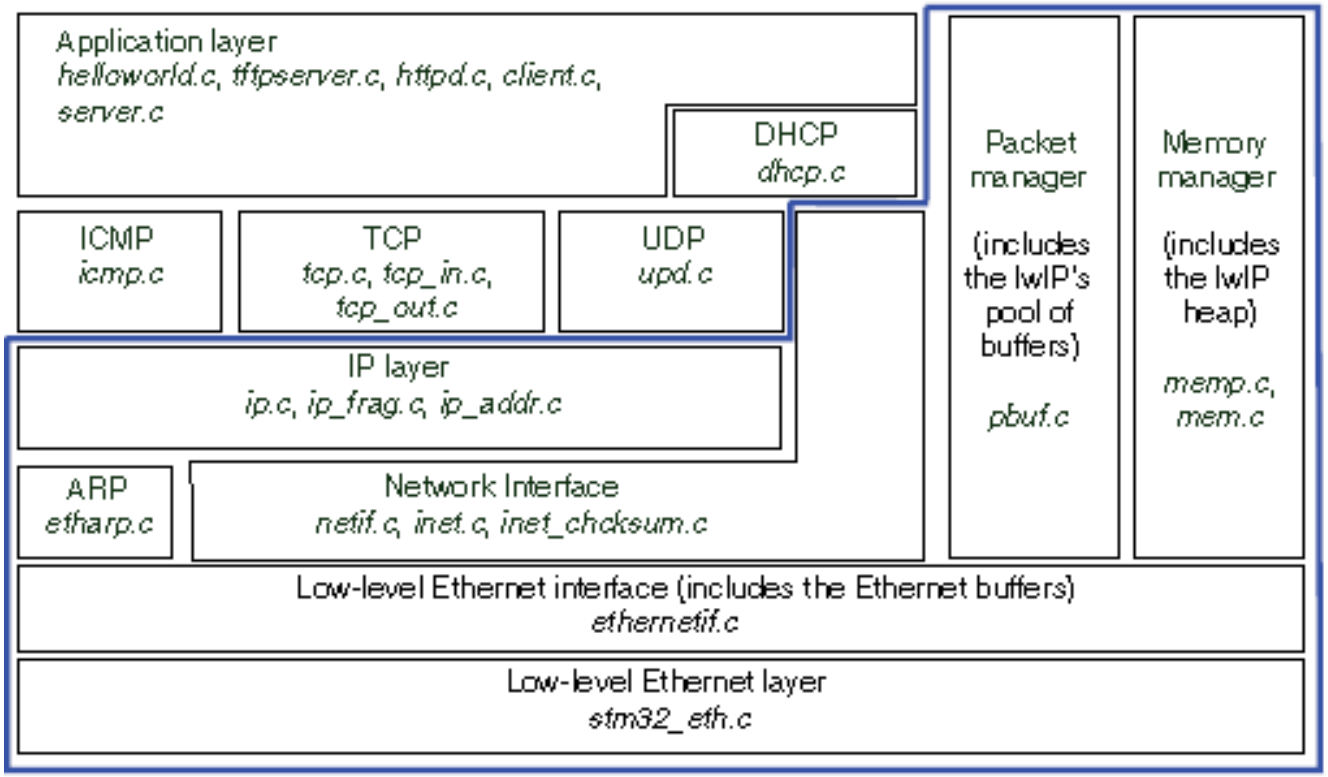
- RMII with one 25MHz crystal



* The NS DP83848 is recommended as the input jitter requirement of this PHY is compliant with the output jitter specification of the MCU

lwIP

- Free TCP/IP Library released by Adam Dunkel.
- (http://savannah.nongnu.org/projects/lwip)
- - Basically support IPv4, IPv6, UDP, TCP, ICMP, IGMP,SNMP, ARP, PPP protocol.
- - HTTPv1.0, TFTP, Telnet protocol are provided as an example in the ST lwIP package.
- - reference : "lwIP TCPIP stack demonstration for STM32F107xx connectivity line microcontrollers.pdf" on the www.st.com



lwIP Porting Tips

- 1.Ethernet Controller I/F low level functions
- -Utilities\lwip-1.3.1\src\netif**ethernetif.c**
- Libraries\STM32_ETH_Driver**stm32_eth.c**

- 2.lwIP Periodic functions(**LwIP_Periodic_Handle**) in **netconf.c**

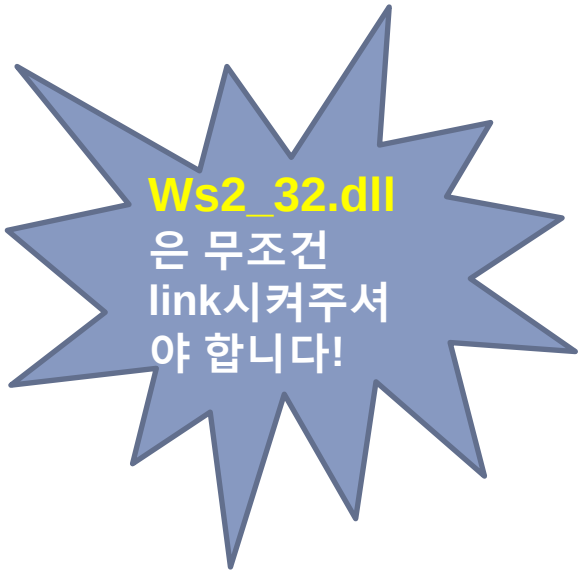
- 3.**lwipopts.h** :: need to set Memory & Options.
- Ex) #define CHECKSUM_BY_HARDWARE //: enable H/W Checksum.

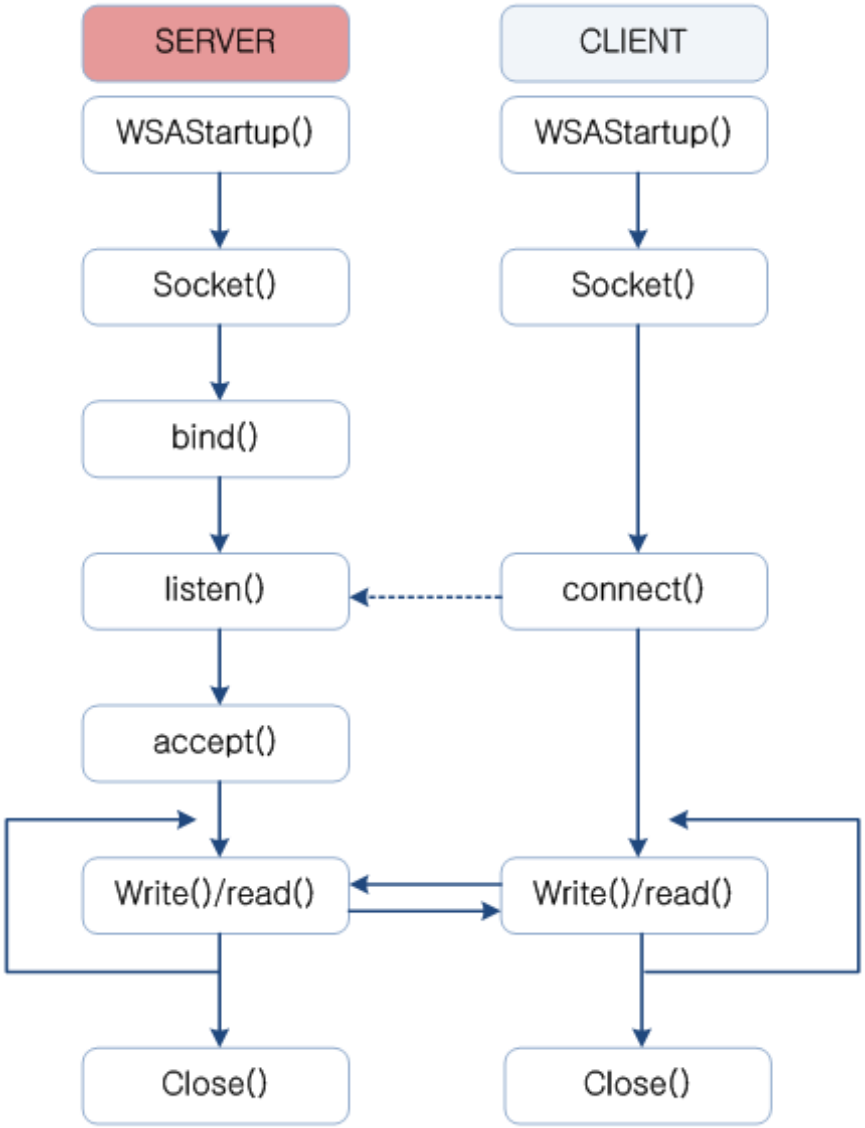
- 4.**stm32f1x7.c** - MII/RMII selection
- #define RMII_MODE
- OR #define **MII_MODE**

- 5.The MAC address is set in the **netconf.c** file (under \Project\src).
- By default, 0.0.0.0.0.7

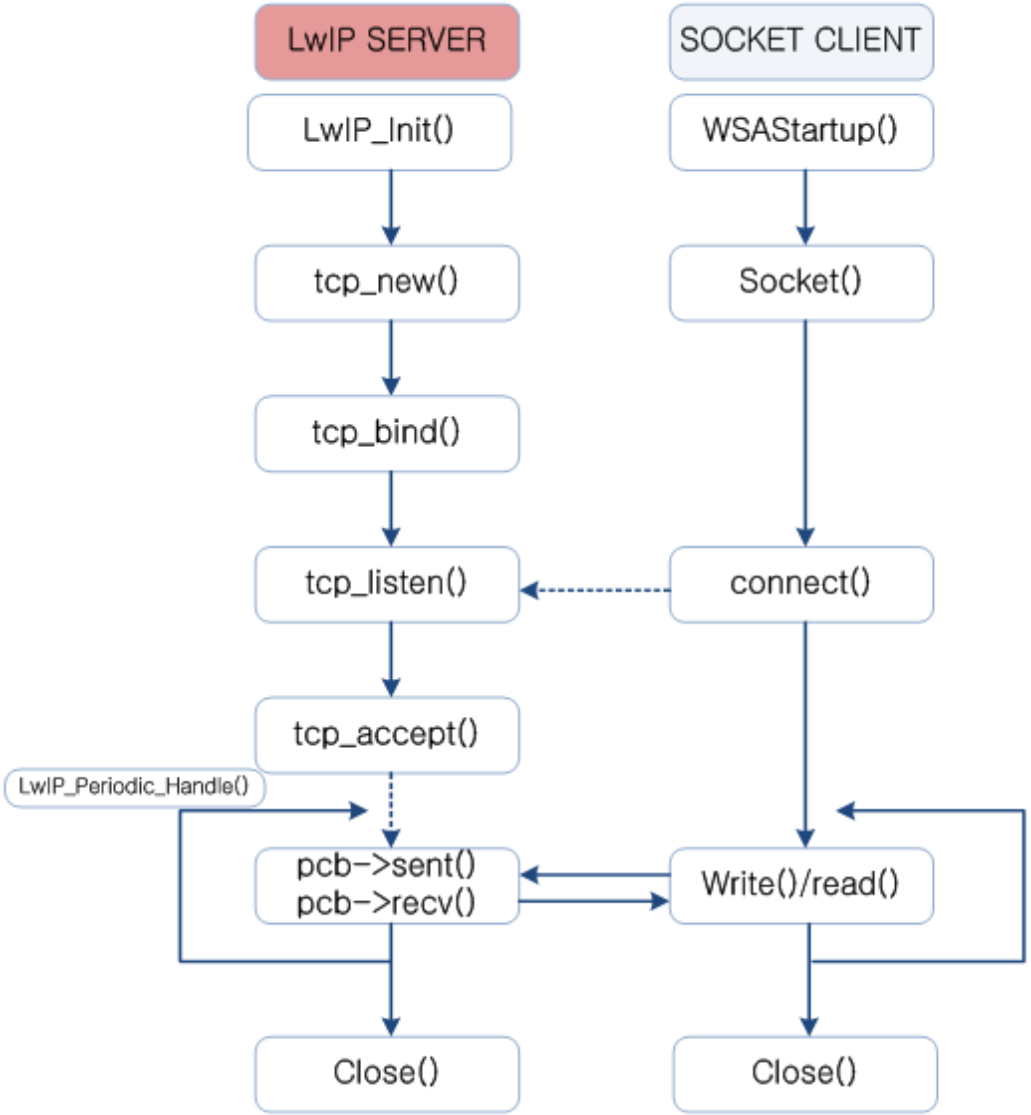
- 6.IP Address is set.
- Ex) **IP4_ADDR**(&ipaddr, 192, 168, 0, 8);

PC용 SOCKET SRV/CLIENT P/G 구조





LwIP Srv & SOCKET Client PG구조



PC용 SOCKET Client P/G

```
//0.TCPIP설정을 위한 기본 초기화 함수
WSAStartup(wVersionRequested, &wsaData);

// 1.      주소 정보에 서버의 주소와 포트번호를 지정하고 Socket을 생성.
addr.sin_family      = AF_INET;
addr.sin_port        = htons(port);
addr.sin_addr.s_addr = inet_addr("192.168.0.8");//INADDR_ANY;
sock = socket(PF_INET, SOCK_STREAM, 0);

//2.      서버와의 연결을 시도합니다
connect( sock, (struct sockaddr*)&addr, sizeof( addr) );

//3.      접속에 성공하면 데이터를 전송합니다
send( sock, &strX[0], 100, 0); // strX 배열 100 byte전송
recv( sock, &buff[offset], 100, 0); // buff 배열 100 byte 수신

//4.      socket 을 소멸하여 통신 작업을 완료합니다.
closesocket(sock);// 소켓 소멸
WSACleanup();
return 0;
```

LwIP Server P/G

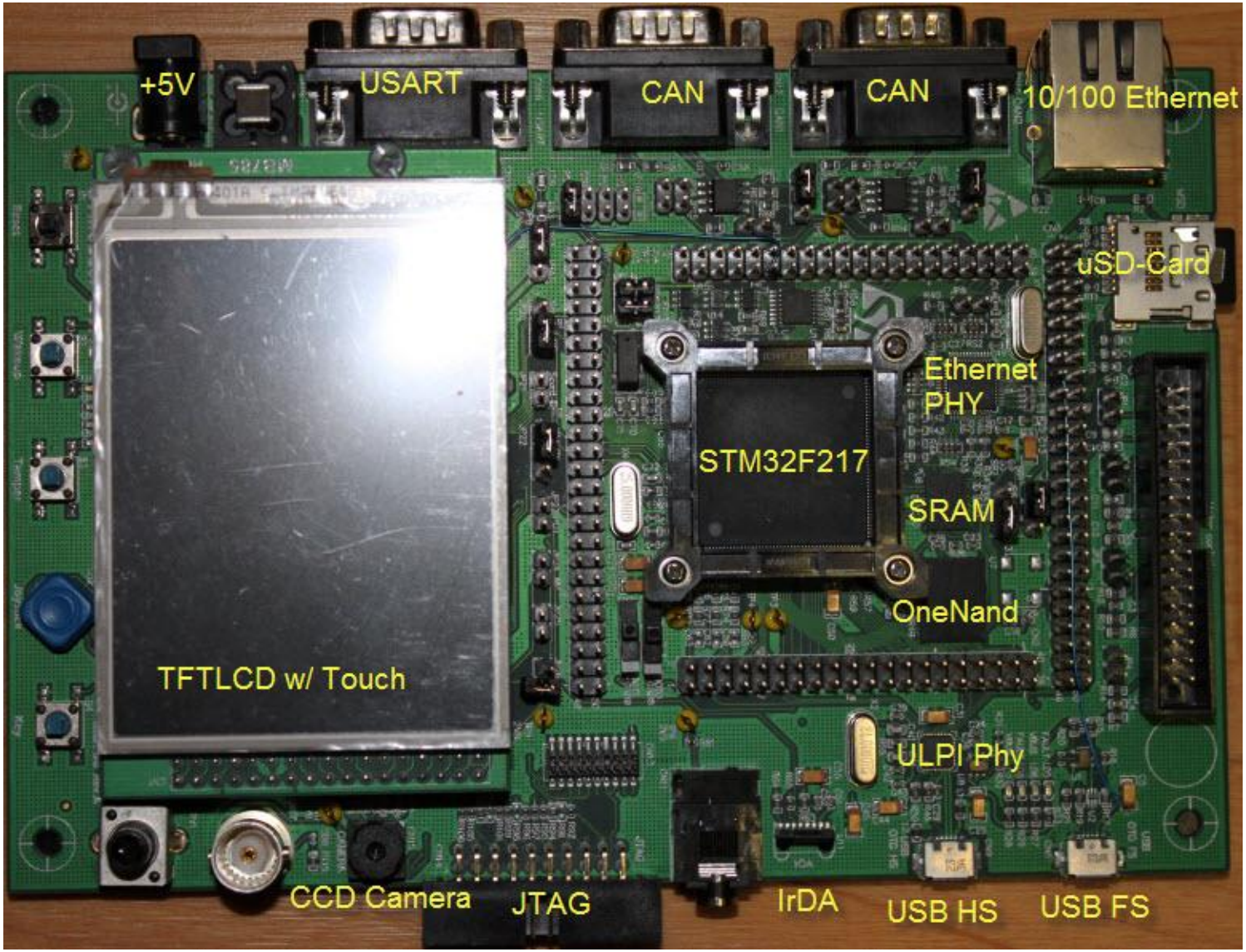
```
//0.기본적인 메모리초기화 및 IP(default :192.168.0.8)를 셋팅합니다.
LwIP_Init();

//1.필요한 peripheral에 대한 초기화를 합니다.
system_init();

//2.pcb(protocol control block) structure를 생성합니다.
pcb = tcp_new();

//3.pcb구조체에 IP주소,port번호 등을 등록합니다.
tcp_bind(pcb, IP_ADDR_ANY, port_number);

//4.client로부터의 접속요청을 기다립니다
pcb = tcp_listen(pcb);

//5.연결이 되면 accept_callback()함수를 등록합니다.
tcp_accept(pcb, accept_callback);

while(1){
  LwIP_Periodic_Handle();//7.tcp read/write를 수행합니다.
}
```

LwIP Server P/G –Callbacks

```
//----------------------//
//Accept_Callback함수//
//----------------------//

//pcb에서 사용한 메모리를 초기화 합니다.
hs = mem_malloc(sizeof(struct buffer));
hs->file = NULL;
hs->left = 0;

// pcb에 정의한 메모리를 등록
tcp_arg(pcb, hs);

/* LwIP callback functions 등록. */
tcp_err(pcb, Error_Callback);
tcp_recv(pcb, Recv_Callback);

return ERR_OK;
```

```
//----------------------//
//Receive_Callback함수//
//----------------------//

//pcb의 user버퍼주소를 넘겨받음.
 struct buffer*hs;
 hs = arg;

 //설정 개수만큼 데이타를 복사한다.
 tcp_recved(pcb, p->tot_len);

 // 데이타 전송.
 tcp_write(pcb, hs->file, len, 0);

 return ERR_OK;
```

STM3220G-EVAL Board



Development Tools

Hardware Debugging Tools

- **ST-Link** : from STMicroelectronics
- **R-Link** : from Resoinance
- **J-Link** : from Segger
- **U-Link** : from Keil

EvoPrimer

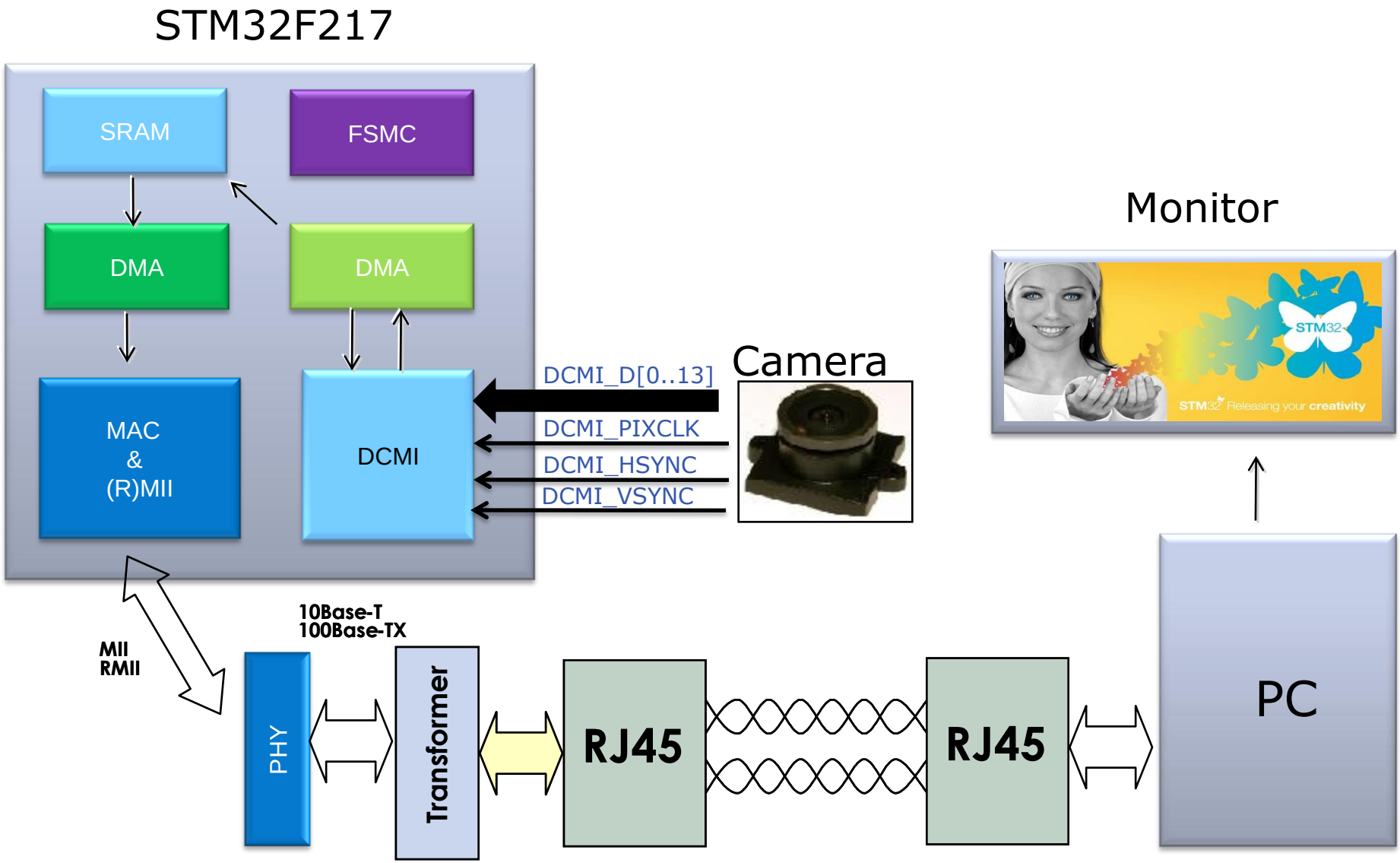
Compiler Toolchain for STM32F2xx

- RealView uVision Development kit(**RVMDK**): from Keil, recommend v4.20
- Embedded Workbench for ARM(**EWARM**) : from IAR, recommend v6.10 or v6.10.5
- **TrueSTUDIO** Lite version for STM32: A dedicated patch (gdbserver.exe) exist.
- **RIDE7**/Rflasher: RIDE version V7.30 and Rkit v1.31.
- **Tasking**: v3.2r1.

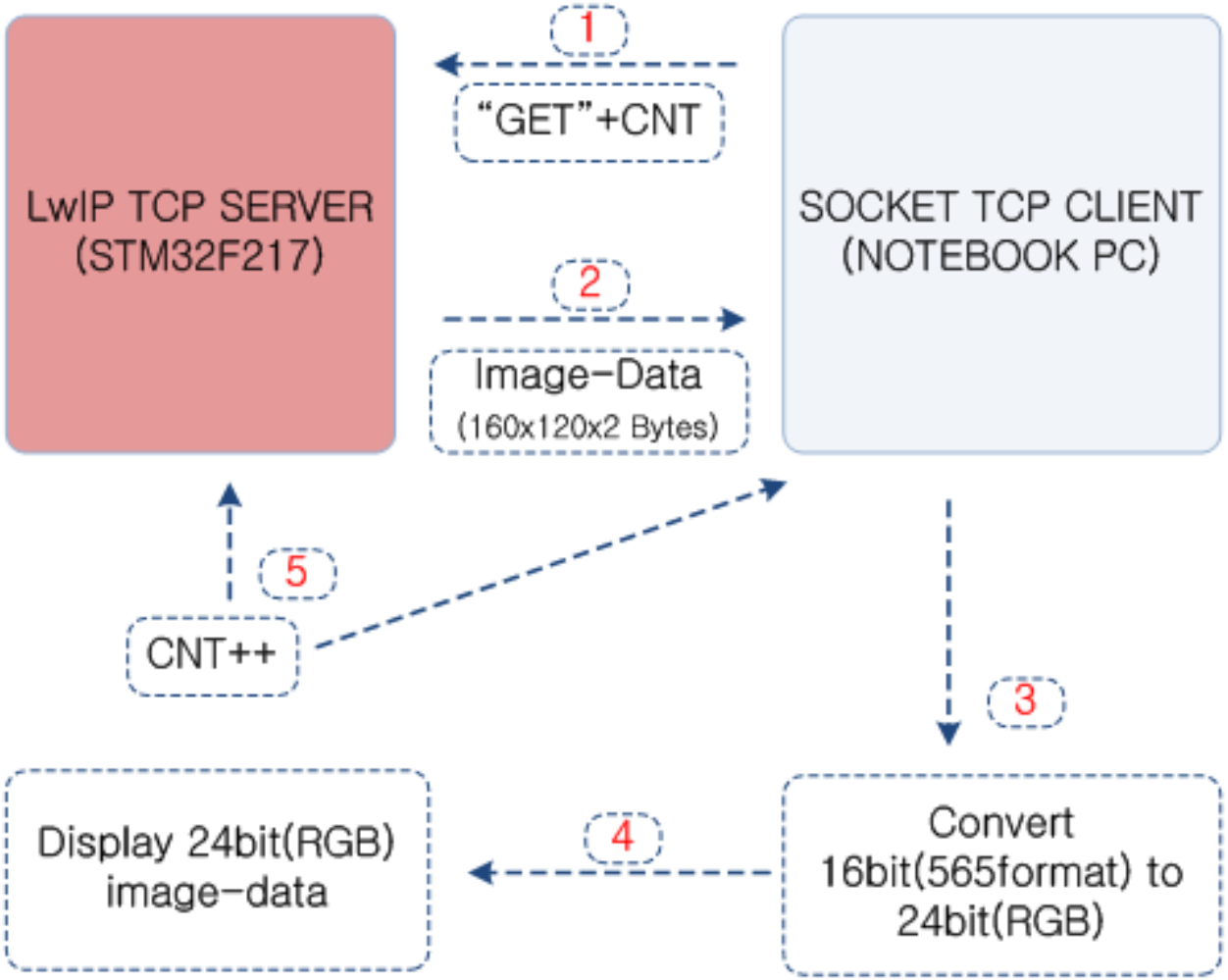
Programming Tool Companies

- SEGGER, HI-LO Systems, ELNEC, Bpmicrosystems, Dataman, DataIO, Leap Electronics, Phyton, RK-System, System General, SMH Technologies, Xeltek

Ethernet IP-CAM Interface



IP-CAM Example : Protocol



DEMO

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