School of Mechanical Engineering
FACULTY OF ENGINEERING

UNIVERSITY OF LEEDS

MECH5170M
Connected and Autonomous Vehicles Systems

Latency of on-board and online services

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Latency

5G latency

Third-generation mobile networks 3G had latencies in the **hundreds of milliseconds**.

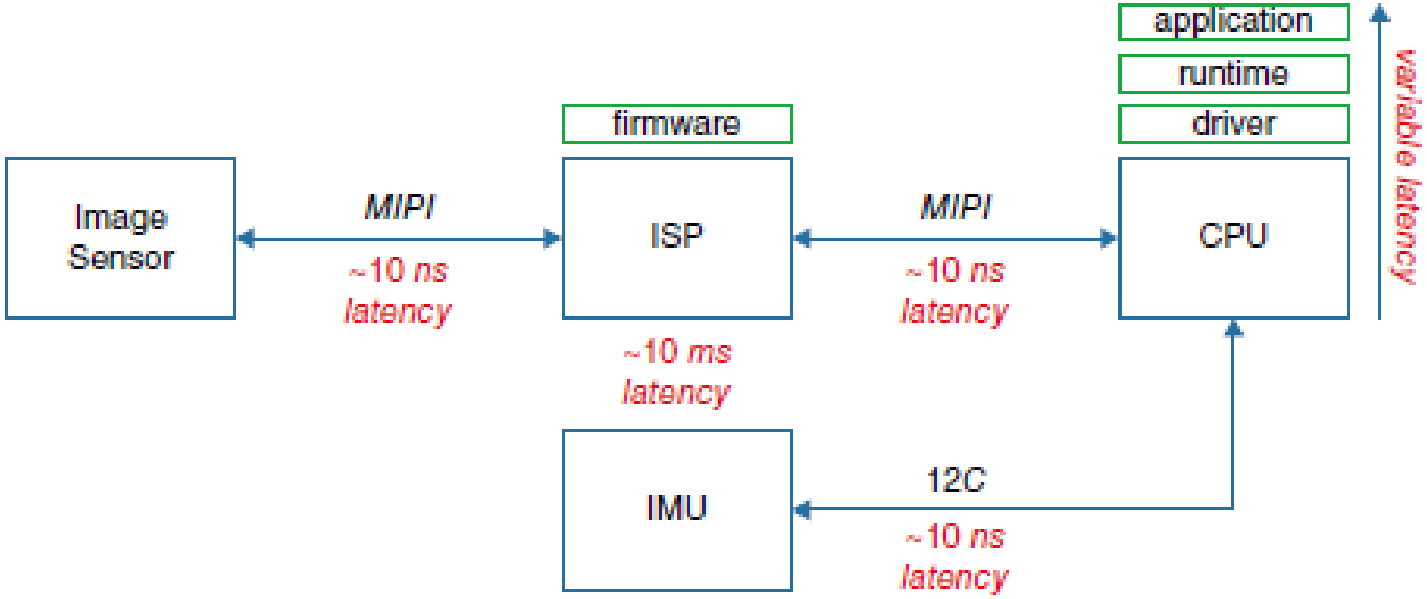
4G networks started with latencies of about 100ms and now are down to a range of about **30ms to 70ms**. That's getting closer to the theoretical 4G latency of just 10ms.

With 5G networks, with good networks somewhere between 5ms and 20ms. But that's just today's latency. The ultimate goal for 5G, set by an industry group called the 3GPP (3rd Generation Partnership Project) hopes 5G network improvements ultimately can push latency all the way **down to 1ms**.

Latency

Latency **is the time it takes for data to pass** from one point on a network to another.

Latencies between CMOS image sensor and ISP, and ISP and CPU, are both roughly 10 ns



DragonFly+ hardware architecture

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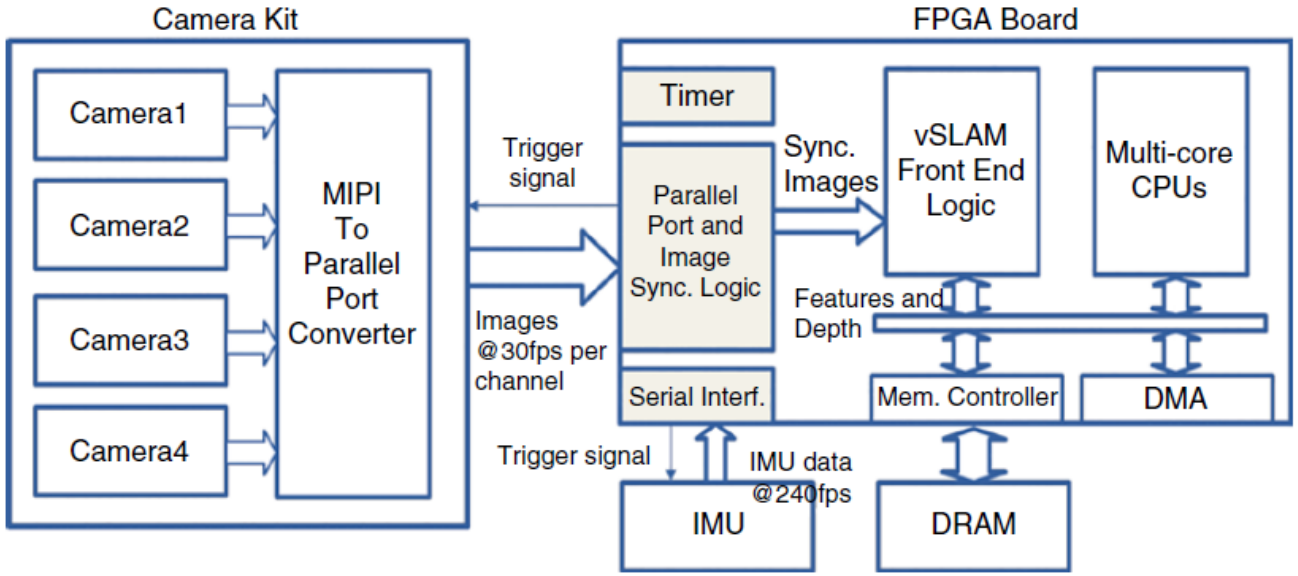
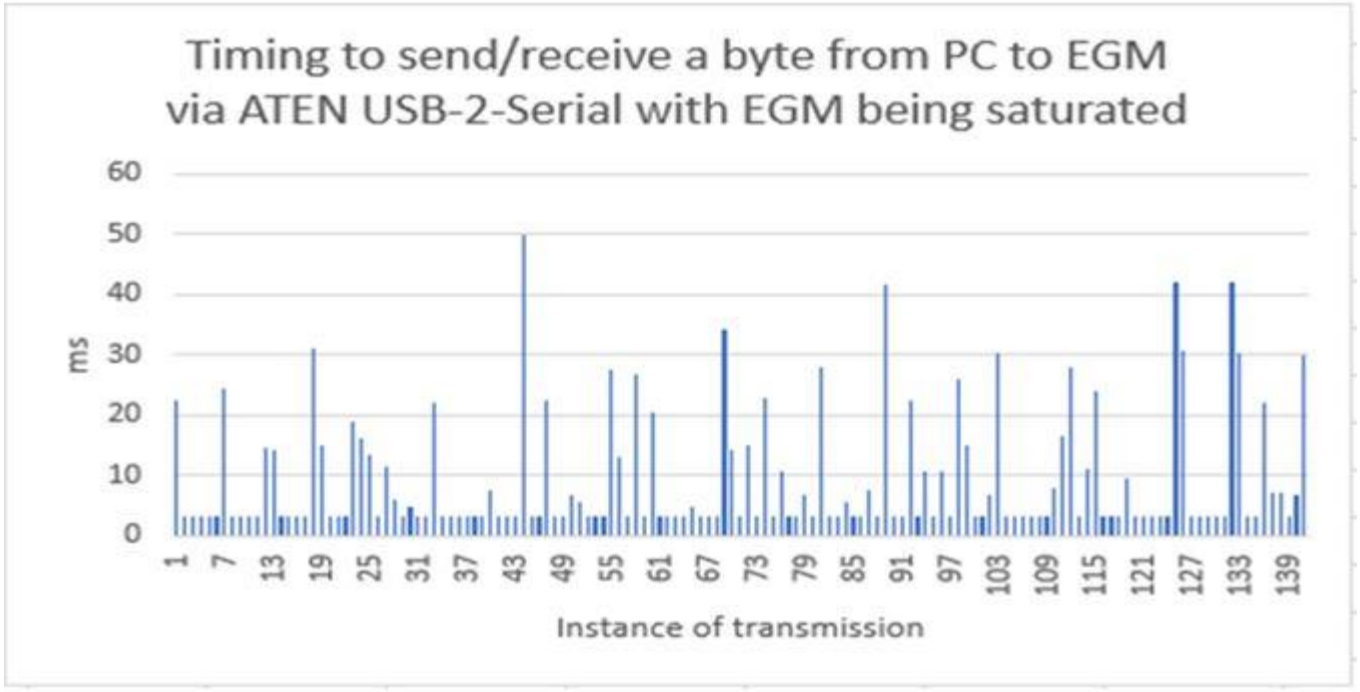
Hardware Synchronisation

If the left image comes in 100 ms after the right image, then there is no way you can generate accurate depth information, especially when you deploy this computer vision device on a moving vehicle.



Serial Communication latency USB



Arduino Serial COM latency

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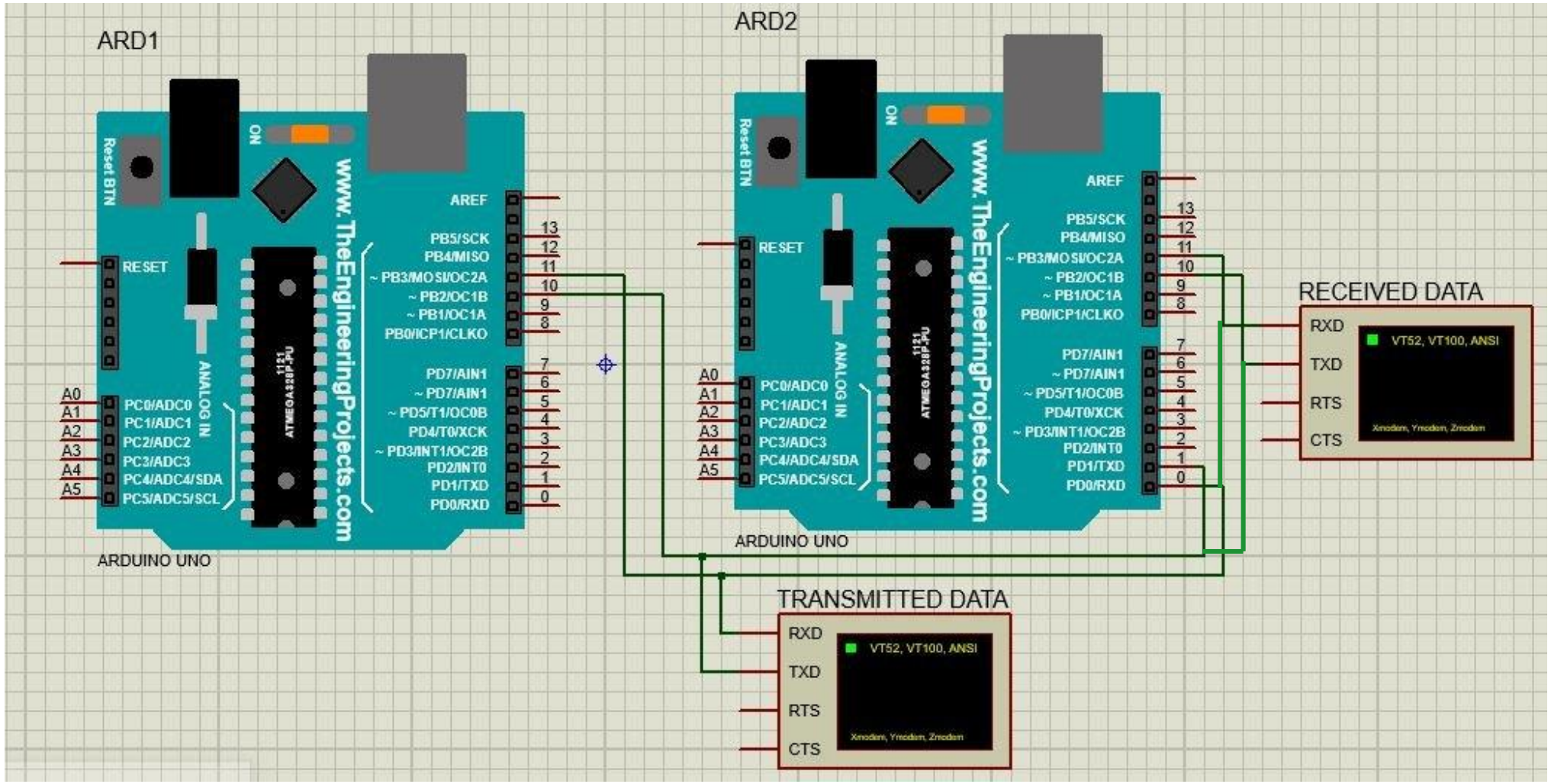


Arduino Serial COM latency

Serial_Master | Arduino 1.8.6

File Edit Sketch Tools Help

Serial_Master §

```
#include <SoftwareSerial.h>
SoftwareSerial softSerial(10, 11);

char packet;
unsigned long TimeSend;
unsigned long TimeReceived;
bool dataReceived;

void setup(){
  Serial.begin(9600);
  softSerial.begin(9600);
}

void loop(){
  dataReceived = false;
  TimeSend = micros();
  softSerial.write("A");
  while (!dataReceived){
    if (softSerial.available()){
      packet=softSerial.read();
      TimeReceived = micros();
      Serial.print(packet);
      Serial.println(TimeReceived - TimeSend);
      dataReceived = true;
    }
  }
```

Serial_Receiver | Arduino 1.8.6

File Edit Sketch Tools Help

Serial_Receiver §

```
#include <SoftwareSerial.h>
SoftwareSerial softSerial(10, 11);
char packet;

void setup()
{
  softSerial.begin(9600);
}

void loop()
{
  if (softSerial.available())
  {
    packet = softSerial.read();
    softSerial.print(packet);
  }
}
```

Auto Format finished.

```
Sketch uses 2272 bytes (7%) of program storage space. Max
Global variables use 126 bytes (6%) of dynamic memory, le
```

18 Arduino/Genuino Uno on COM3

COM6 (Arduino/Genuino Uno)

```
A2052
A2052
A2052
A2052
A2052
A2060
A2052
A2052
A2052
A2052
A2052
A2052
A2052
```

9600 b/s

COM6 (Arduino/Genuino Uno)

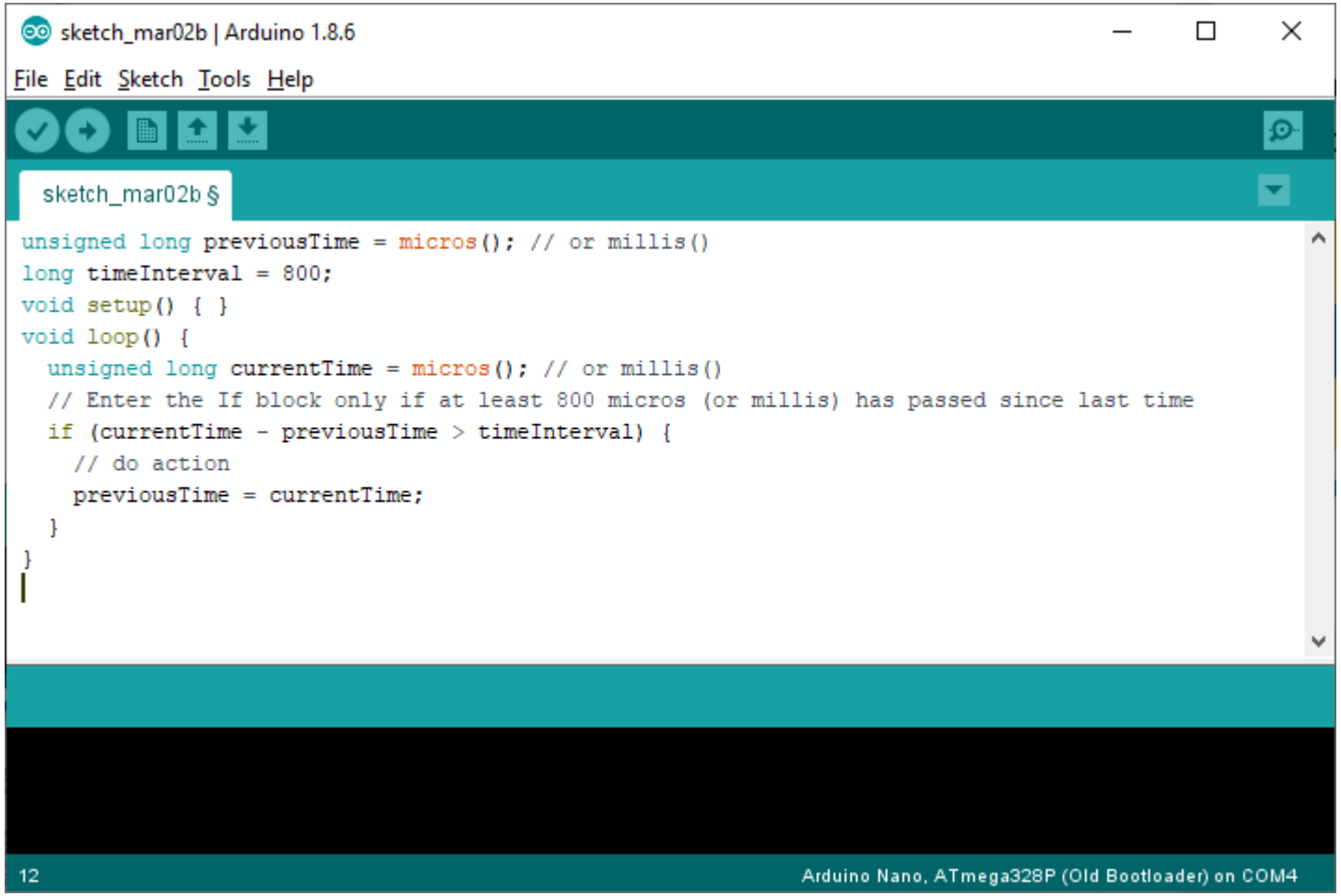
```
A232
A232
A256
A240
A224
A232
A232
A232
A232
A232
A232
A232
A232
A232
A232
```

115200 b/s

Arduino time measurement

Functions:

- millis()
- micros()



Enternet Latency

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ping 81.99.6.43

ping google.jp

ping google.fr

ping google.co.uk

ping google.com

```
Pinging 81.99.6.43 with 32 bytes of data:
Reply from 81.99.6.43: bytes=32 time=28ms TTL=46
Reply from 81.99.6.43: bytes=32 time=25ms TTL=46
Reply from 81.99.6.43: bytes=32 time=29ms TTL=46
Reply from 81.99.6.43: bytes=32 time=27ms TTL=46

Ping statistics for 81.99.6.43:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 25ms, Maximum = 29ms, Average = 27ms
```

```
[2023-03-02 10:56.52]  ~
[menkku.mech-pc6268] ▸
```

```
[2023-03-02 10:56.52]  ~
[menkku.mech-pc6268] ▸ ping google.jp


Pinging google.jp [142.250.179.227] with 32 bytes of data:
Reply from 142.250.179.227: bytes=32 time=8ms TTL=110
Reply from 142.250.179.227: bytes=32 time=7ms TTL=110
Reply from 142.250.179.227: bytes=32 time=7ms TTL=110
Reply from 142.250.179.227: bytes=32 time=7ms TTL=110

Ping statistics for 142.250.179.227:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 7ms, Maximum = 8ms, Average = 7ms
```

Conclusions

- Latency could be a significant problem
- Latency is causing problems for signals synchronisation in time

ANY QUESTIONS ???