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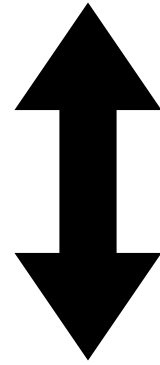
The Promise and Pitfalls of TLV Serialization

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IEEE SA Ethernet & IP @ Automotive Technology Day
São Paulo, Brazil
September 2023

Serialization

structured data



byte string

structured data

```
struct myStruct {  
    int anInteger;  
    int anotherInteger;  
    char aString[80];  
};
```





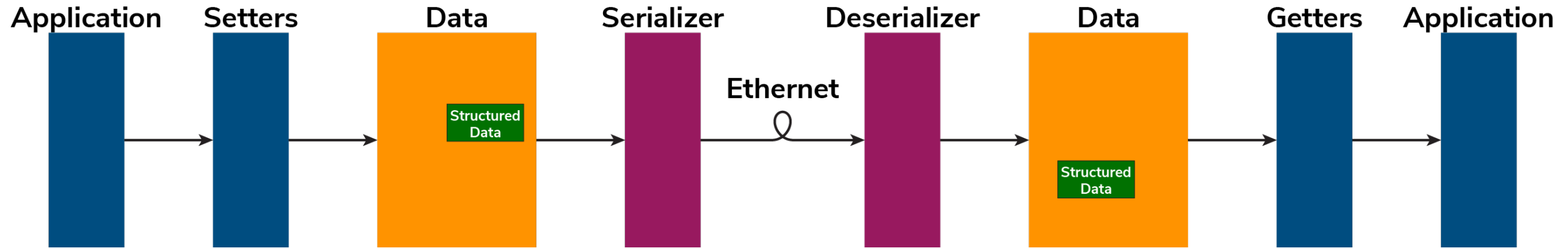
Semantics preservation
Architectural independence
Language independence
Message evolution
Type safety
Efficient setters/getters
On-the-wire efficiency

Remote Procedure Calls (RPCs)

Remote Procedure Calls (RPCs)

$$a = \text{fn}(b)$$

Building Blocks



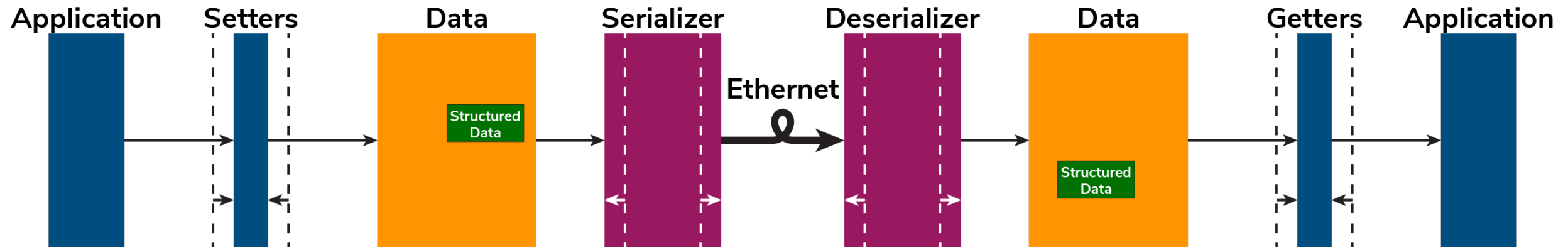
Serialization Categories

Human Readable

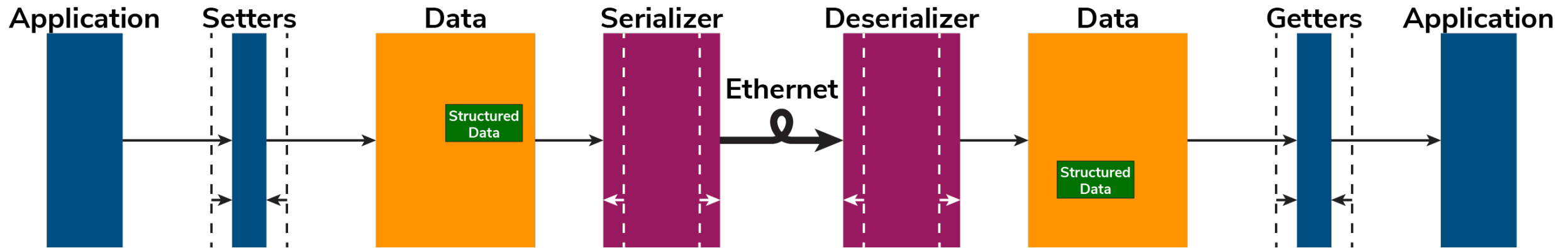
Memory Copy

TLV Tagged

Human Readable

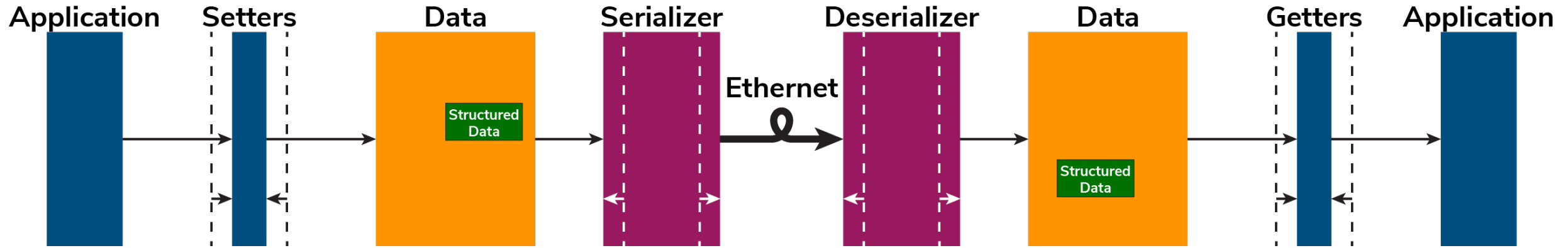


Human Readable



`int8 x = 42` → ““theAnswer”: 42”

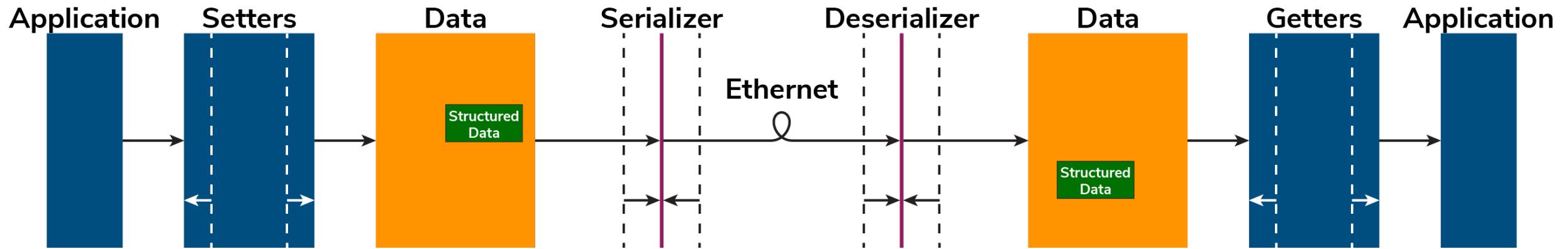
Human Readable



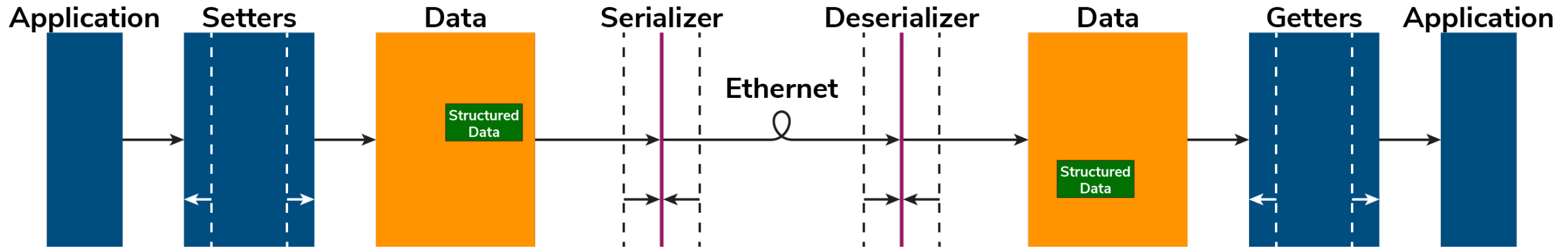
JSON

XML

Memory Copy

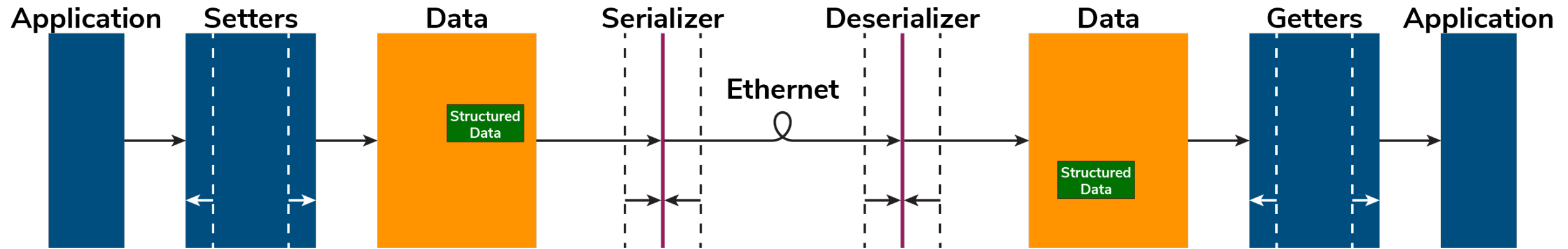


Memory Copy



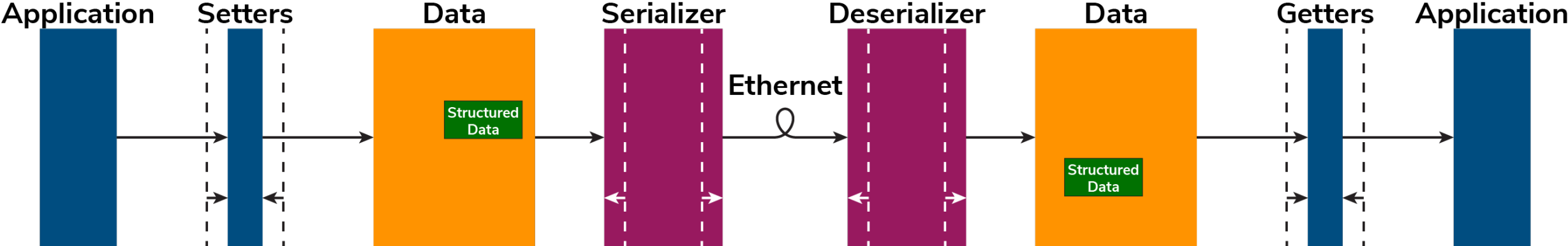
`int64 x = 42 → 0x0000_0000_0000_002a`

Memory Copy

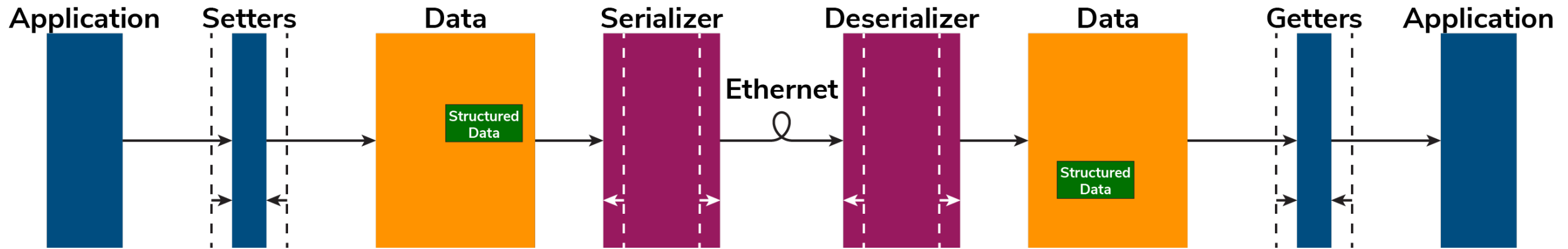


SOME/IP
Cap'n Proto
Flat Buffers

TLV Tagged



TLV Tagged

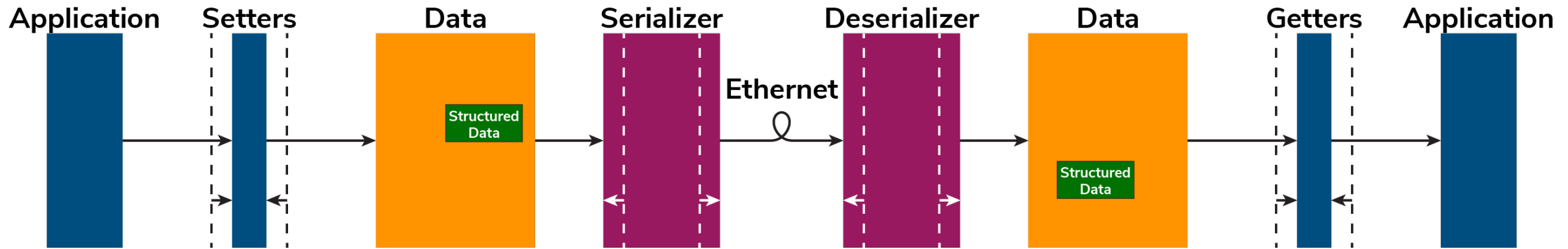


type

ID

length

TLV Tagged



SOME/IP (TLV)

Protocol Buffers

On-The-Wire Efficiency

Tags take space 😞

Exact-fit arrays 😊

Suppression of optional values 😊

Lightweight scalar compression 😊

Protocol Buffers Performance

```
syntax = "proto3";

message BottomLevelMessage {
    string bottomString1 = 1;
    string bottomString2 = 2;
    repeated sint64 arrayOfCompressibleInts = 3;
}

message MidLevelMessage {
    repeated BottomLevelMessage firstBottom = 1;
    repeated string arrayOfStrings = 2;
    string midString = 3;
    bool yesOrNo = 4;
}

message TopLevelMessage {
    MidLevelMessage firstMid = 1;
    MidLevelMessage secondMid = 2;
    string topString = 3;
    repeated double arrayOfIncompressibleDoubles = 4;
}
```

Protocol Buffers Performance

AMD EPYC 7702P @ ~2 GHz

serialized length = 102 Mbytes

serialization time = 2.17 secs = 394 Mbits/s

deserialization time = 1.78 secs = 480 Mbits/s

combined rate = 216 Mbits/s

Protocol Buffers Performance

6 × 10 Gbits/s Ethernet links

216 Mbits/s offered load

0.36% network utilization

Why So Slow?



Why So Slow?

Compression/decompression

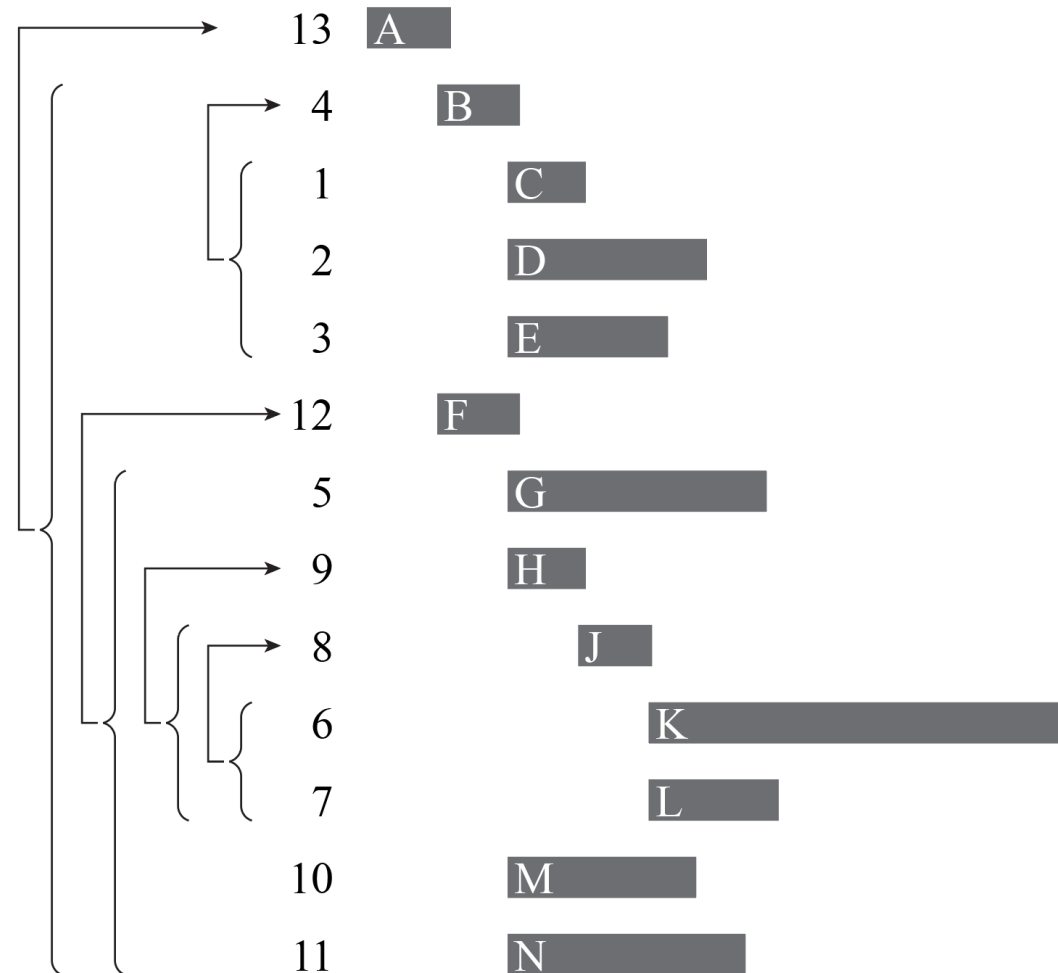
Length determination

Variable-ID mapping

Varint Compression/Decompression

Signed Original	Encoded As
0	0
-1	1
1	2
-2	3
2	4
-3	5
3	6
etc.	etc.

Length Determination



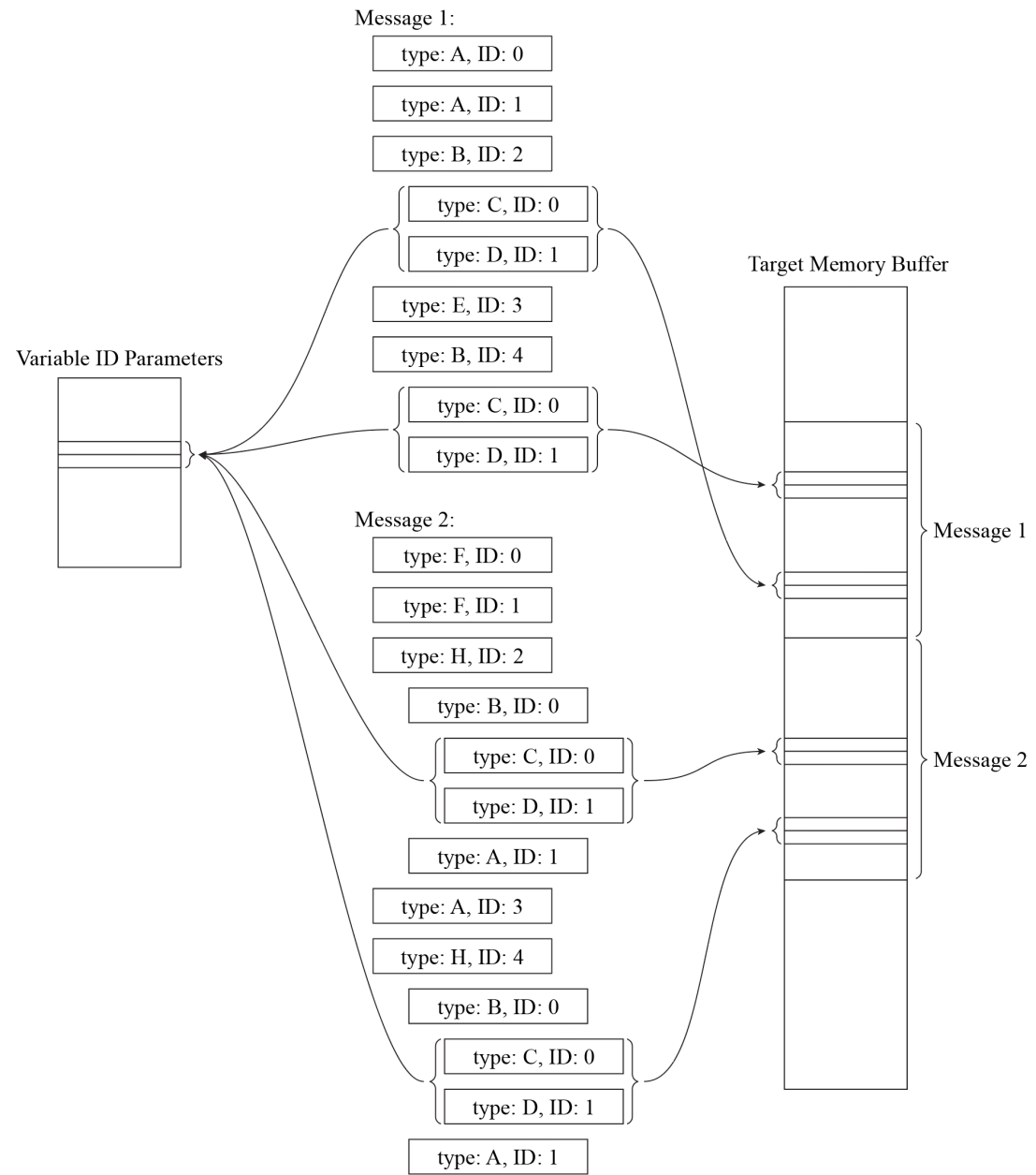
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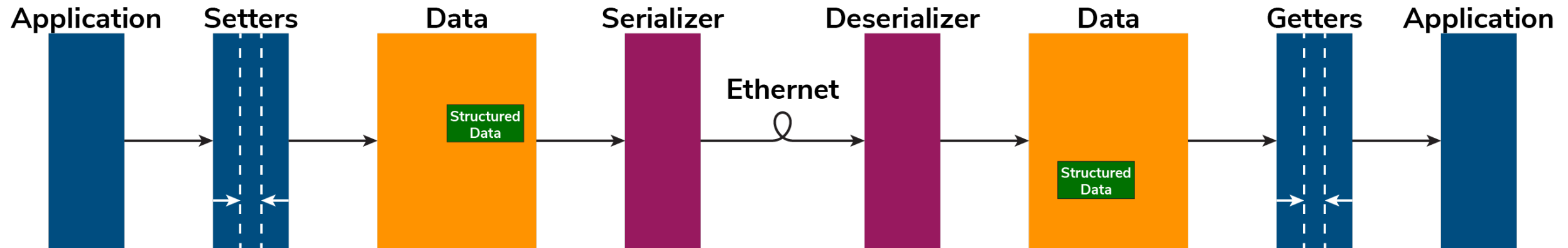
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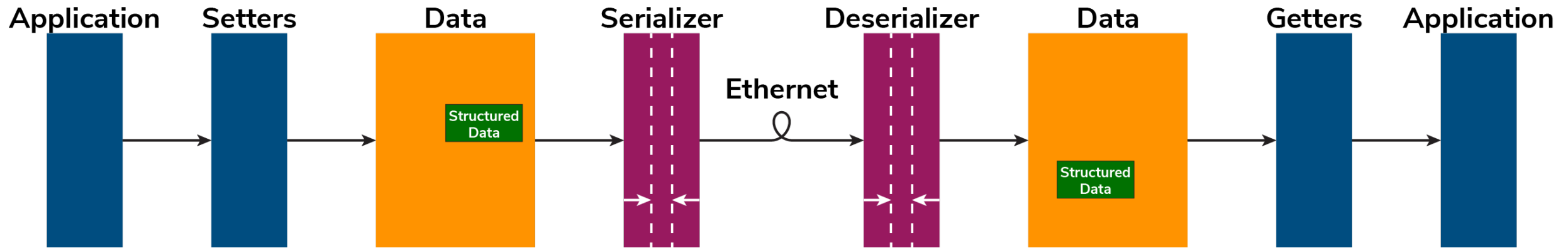
What Can Be Done?



What Can Be Done?



What Can Be Done?



Concluding Thoughts

Increasing structured data communications

Fully-featured serialization

Modern software

Must reduce CPU overhead

Benefit to future Ethernet networks



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Thank You