Prof. Dr. Florian Künzner
Technical University of Applied Sciences Rosenheim, Computer Science

CA 5 – Processor 2

The lecture is based on the work and the documents of Prof. Dr. Theodor Tempelmeier

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Goal

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Goal

CA::Processor 2

- Endianness
- Examples
- Usage
- Transfer
- Solutions

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Endianness

Endianness: The definition of the **byte order** within a **multi-byte word**.

Register view of a 32bit architecture:

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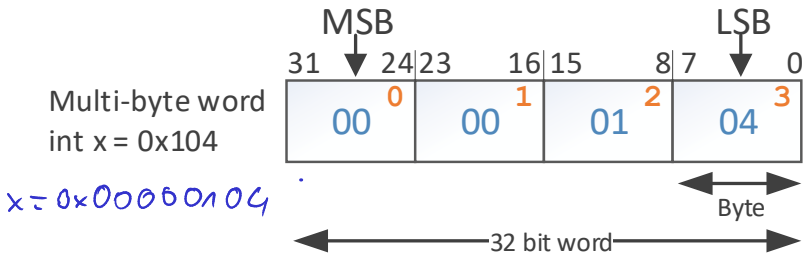
Register view of a 32bit architecture:

Big Endian



x = 0x00000104

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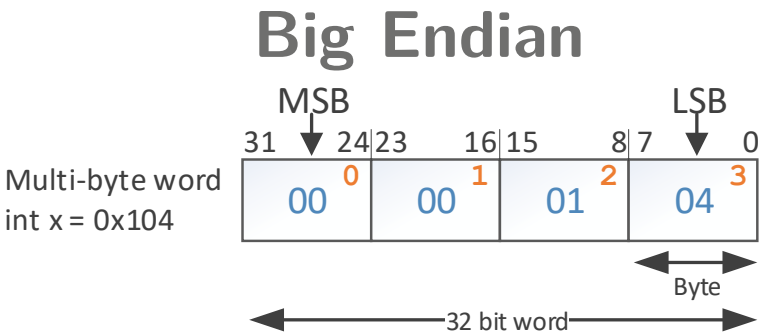

- MSB - Most significant byte
- LSB - Least significant byte

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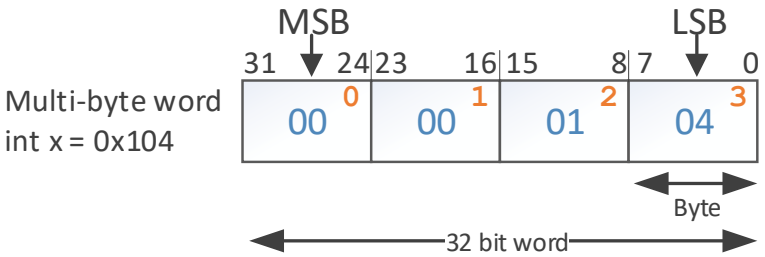
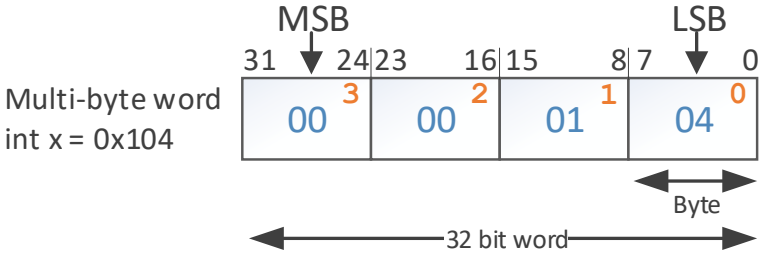


Little Endian



- MSB - Most significant byte
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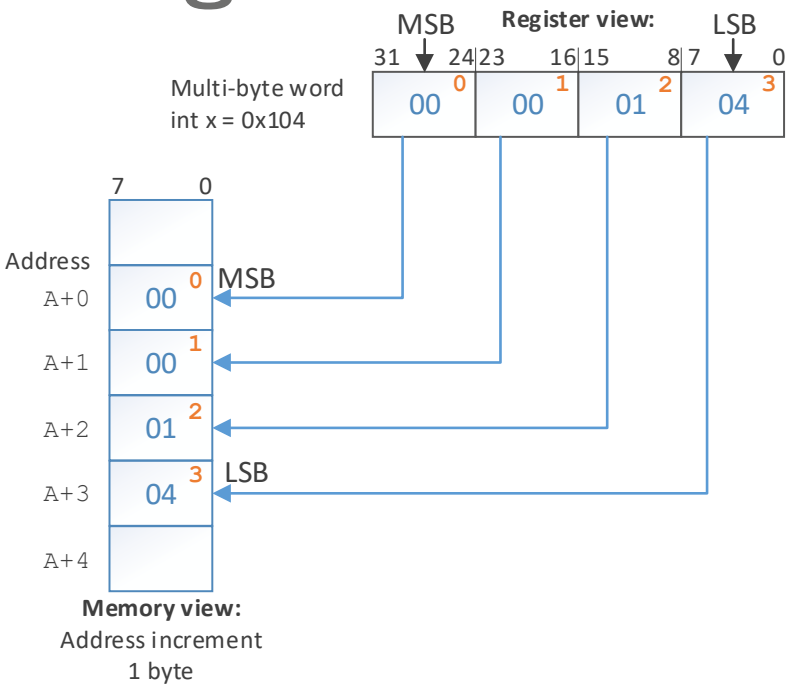
Endianness - Big endian (first)



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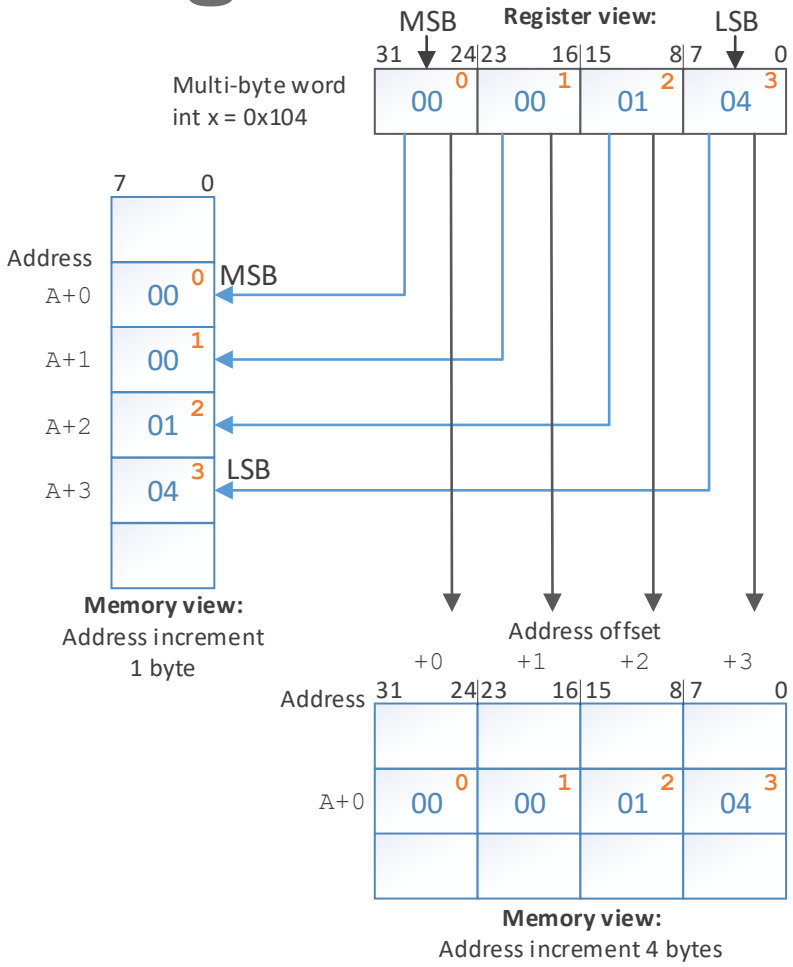

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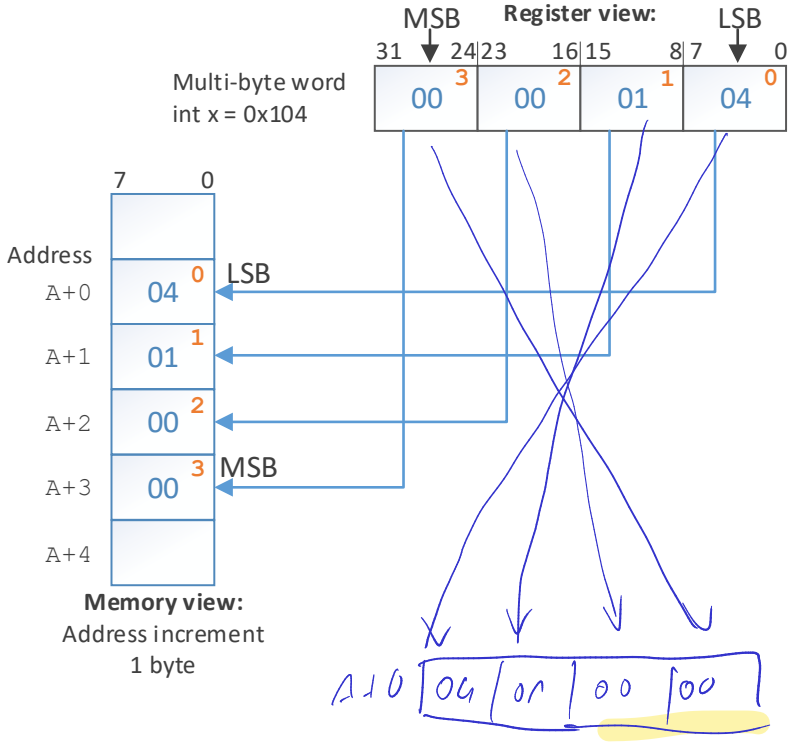
Endianness - Little endian (first)



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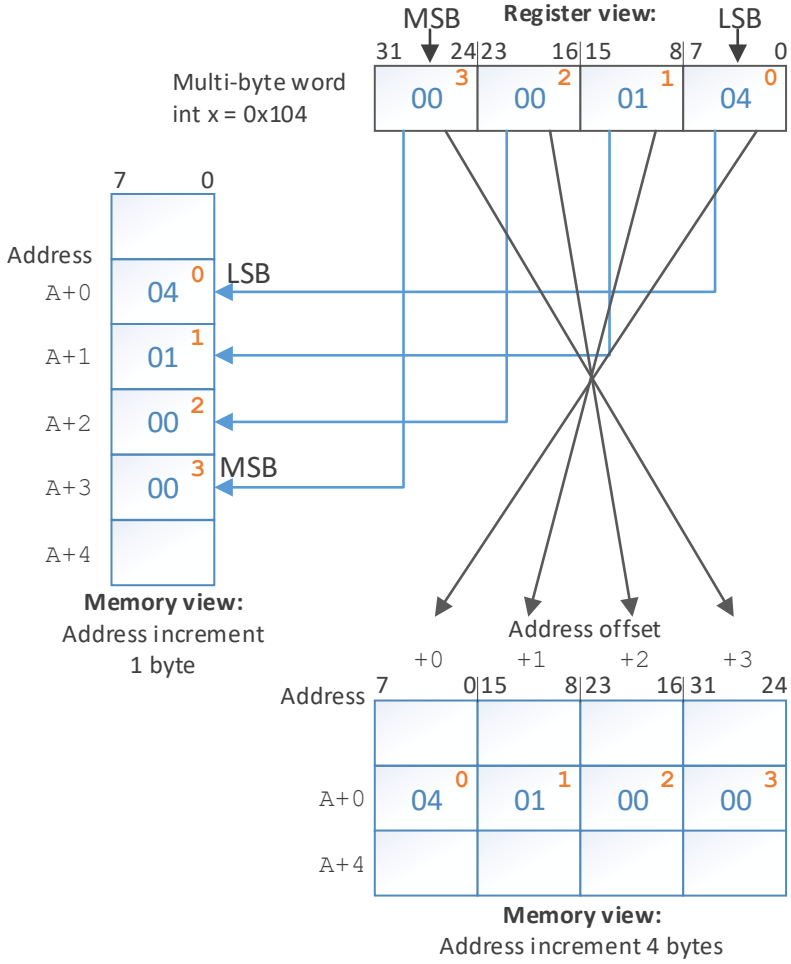
Endianness - Little endian



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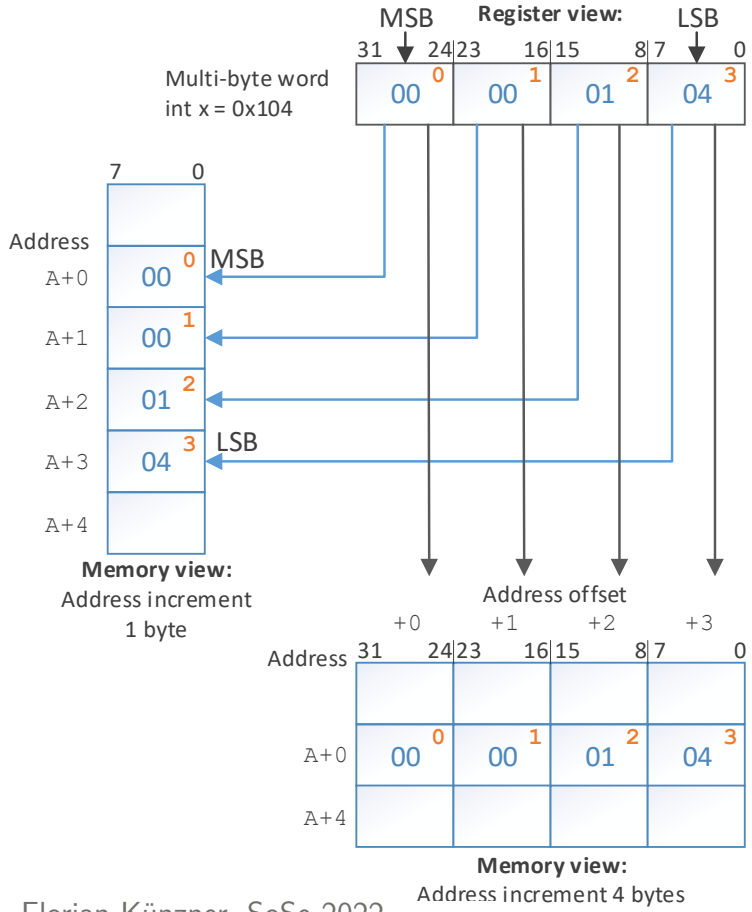
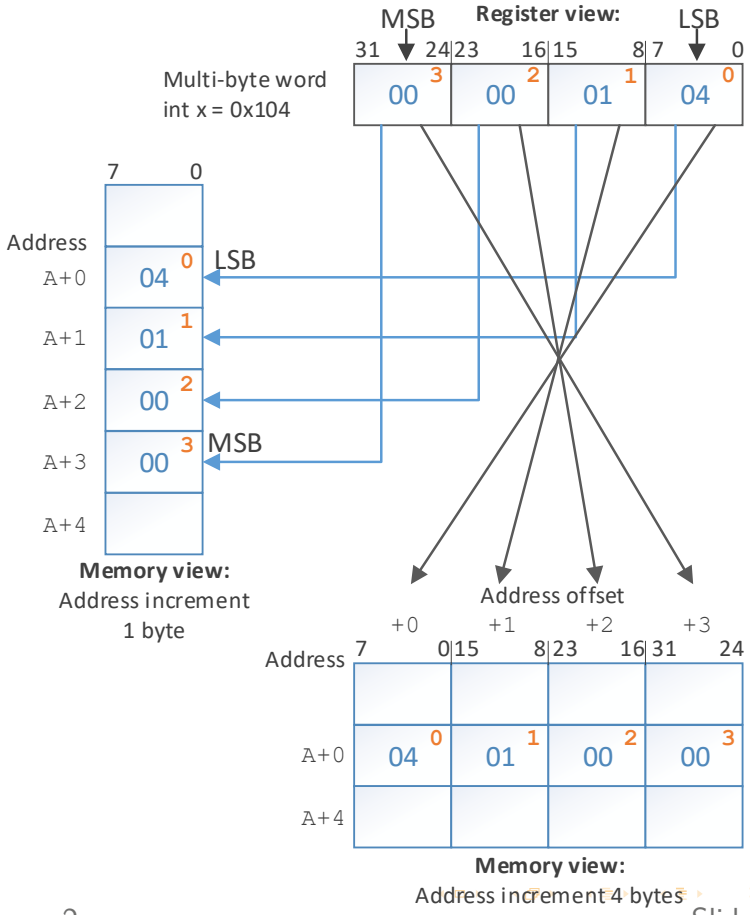
Endianness - BE/LE

Big endian



Little endian



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Endianness - example BE

```
1  #include <stdlib.h>
2  #include <stdint.h>
3
4  int main()
5  {
6      struct employee {
7          char     name[12];
8          uint32_t age;
9          uint32_t dept_nr;
10     };
11
12     struct employee smith = {
13         .name    = "JIM SMITH",
14         .age     = 21,   //0x15
15         .dept_nr = 0x104 //260
16     };
17
18     return EXIT_SUCCESS;
19 }
```

[cmp: [1, p. 95-96]]

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Endianness - example BE

Big endian memory -> Register

```
1  #include <stdlib.h>
2  #include <stdint.h>
3
4  int main()
5  {
6      struct employee {
7          char     name[12];
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9          uint32_t dept_nr;
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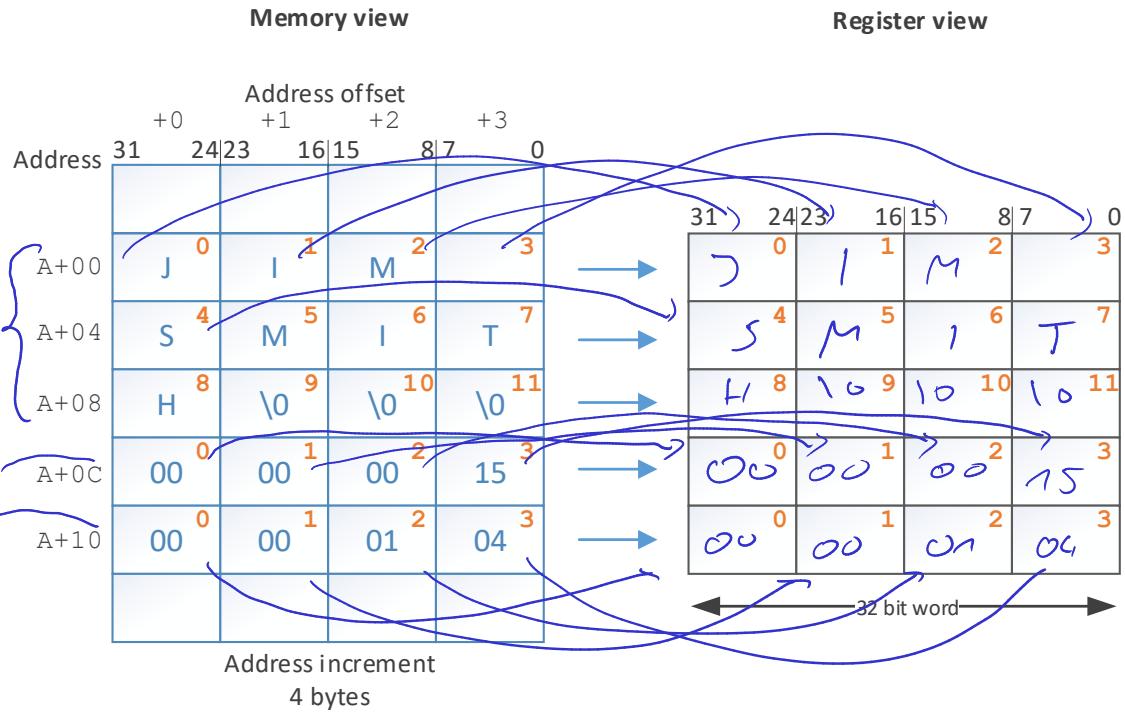

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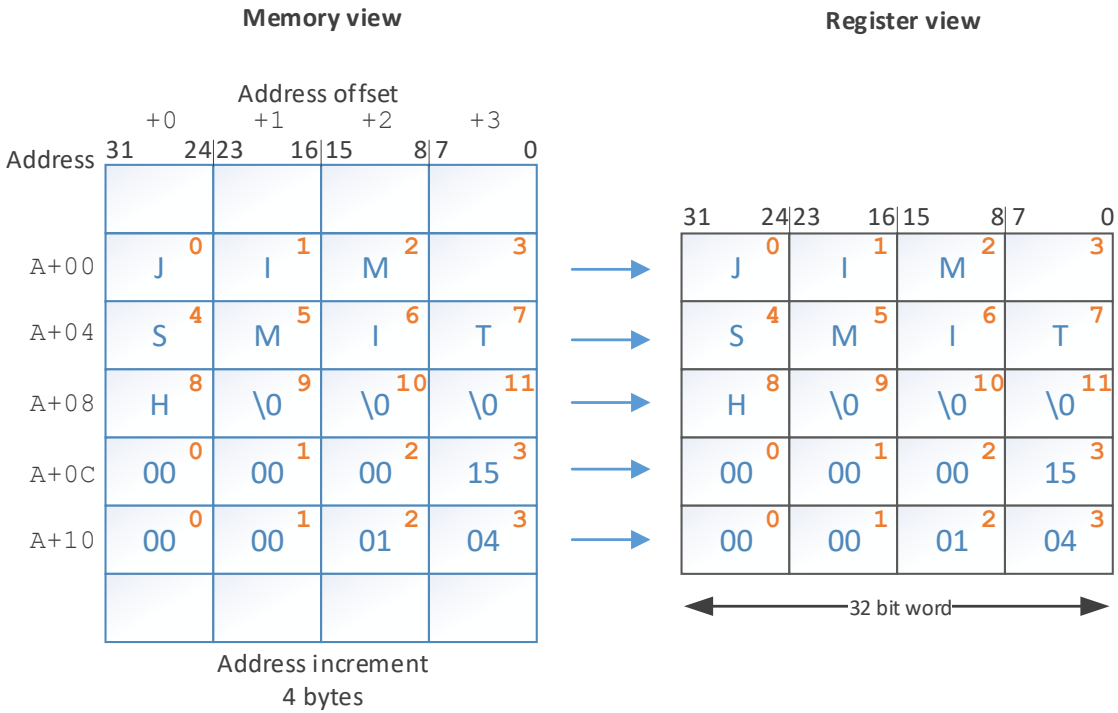

[cmp: [1, p. 95-96]]

Endianness - example LE

```
1  #include <stdlib.h>
2  #include <stdint.h>
3
4  int main()
5  {
6      struct employee {
7          char     name[12];
8          uint32_t age;
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12     struct employee smith = {
13         .name    = "JIM SMITH",
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19 }
```

[cmp: [1, p. 95-96]]

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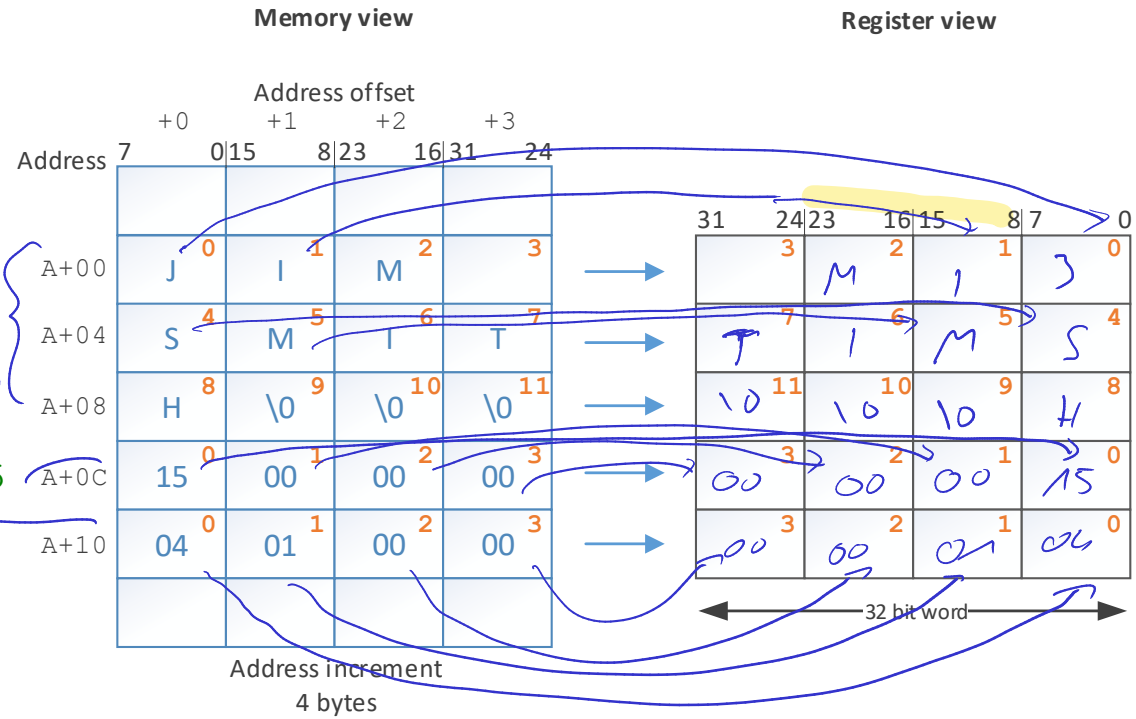
Endianness - example LE

Little endian memory -> Register

```
1  #include <stdlib.h>
2  #include <stdint.h>
3
4  int main()
5  {
6      struct employee {
7          char     name[12];
8          uint32_t age;
9          uint32_t dept_nr;
10     };
11
12     struct employee smith = {
13         .name    = "JIM SMITH",
14         .age     = 21,    //0x15
15         .dept_nr = 0x104 //260
16     };
17
18     return EXIT_SUCCESS;
19 }
```



[cmp: [1, p. 95-96]]

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Endianness - example LE

Little endian memory -> Register

```
1  #include <stdlib.h>
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3
4  int main()
5  {
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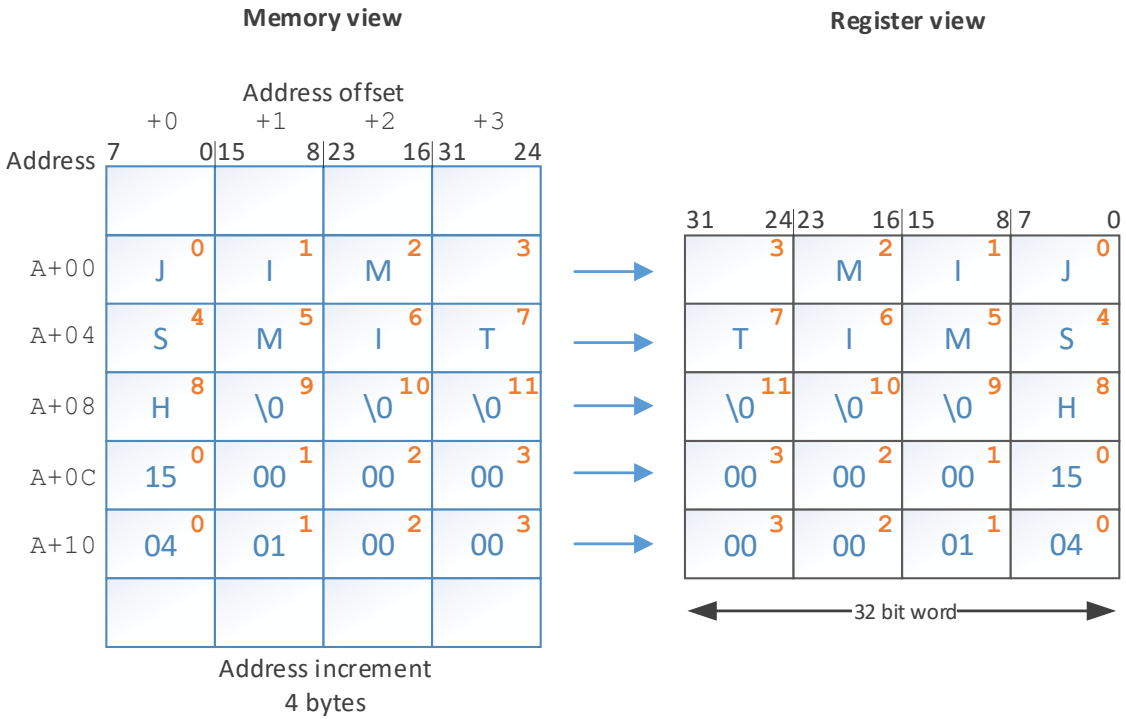

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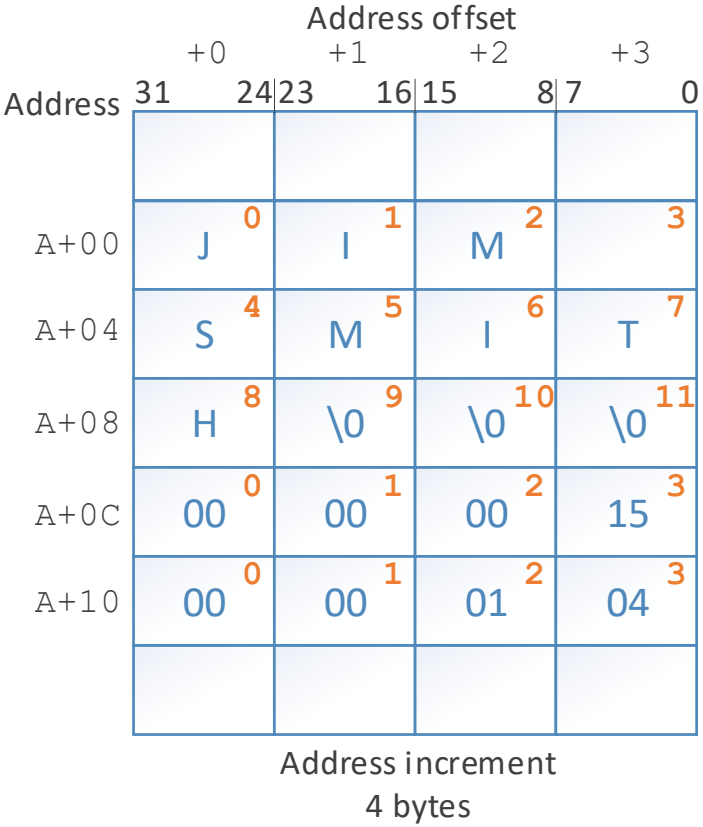
Endianness - example BE/LE

Big endian memory



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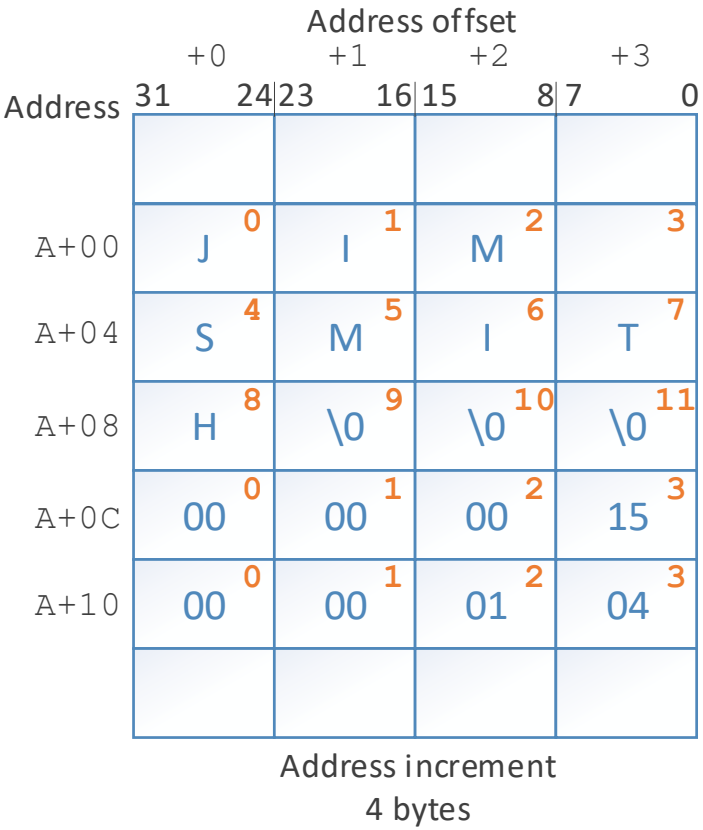
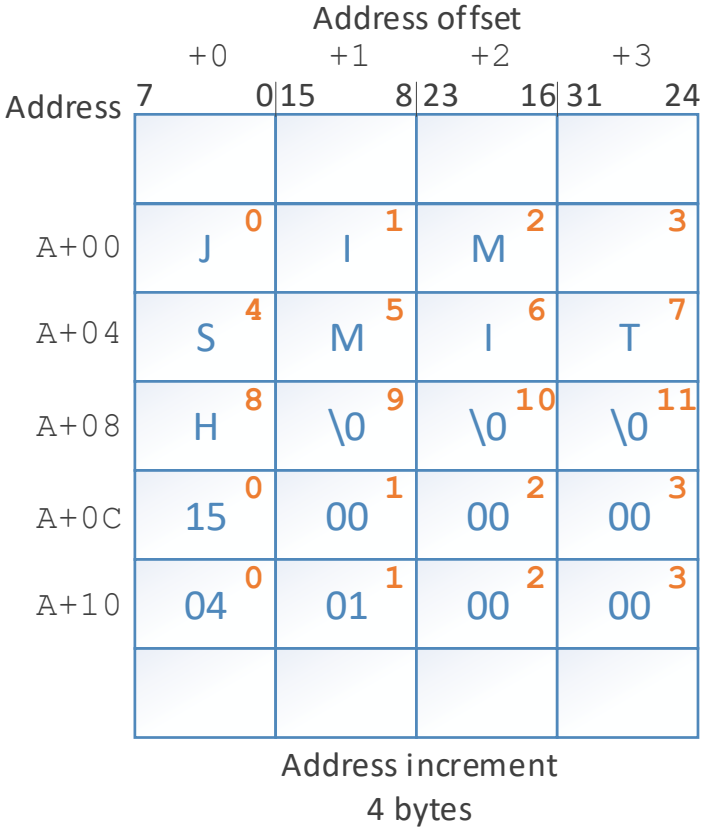
Endianness - example BE/LE

Big endian memory



Little endian memory



[cmp: [1, p. 95-96]]

Endianness - usage

Big endian

- IBM Mainframe
- Freescale ColdFire
- Atmel AVR/AVR32
- ARM Thumb and ARM64 (also Apple M1)

Little endian

- Intel x86
- x86-64 (AMD64, Intel 64)
- RISC-V
- Qualcomm Hexagon

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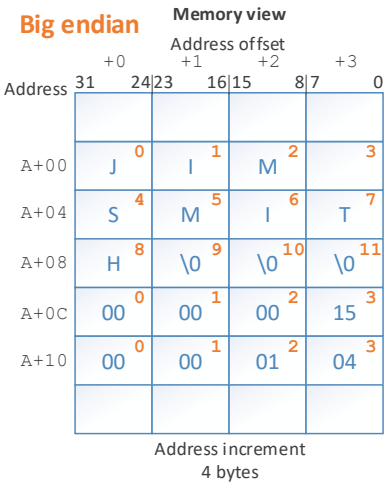
Endianness - transfer: BE to LE



[cmp: [1, p. 95-96]]

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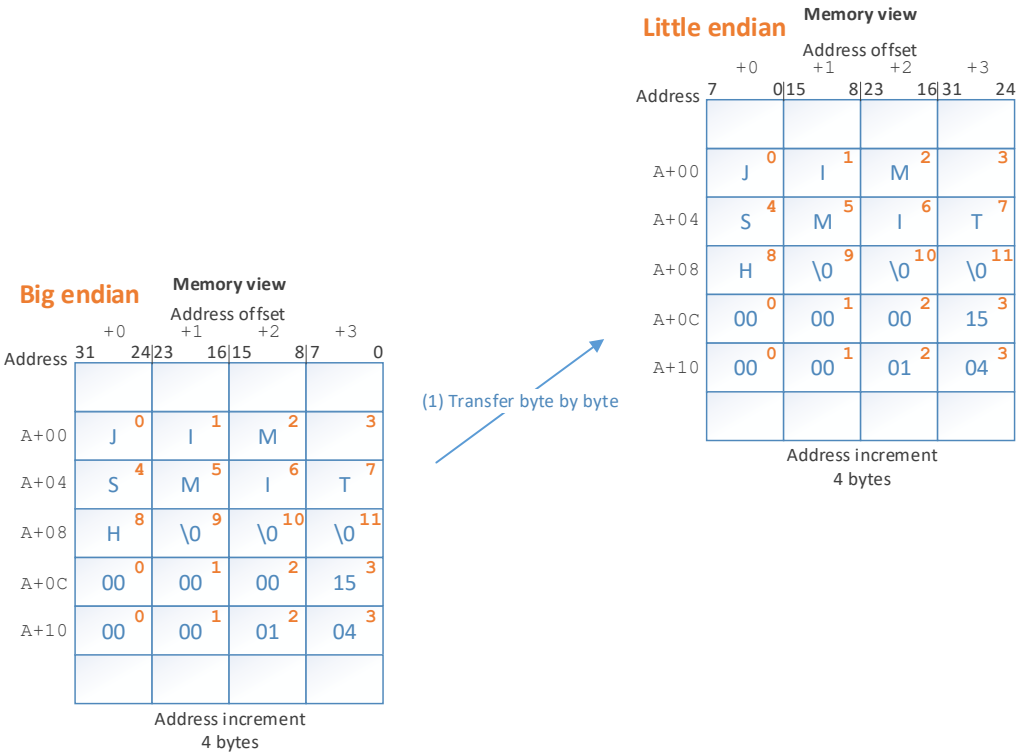
Endianness - transfer: BE to LE



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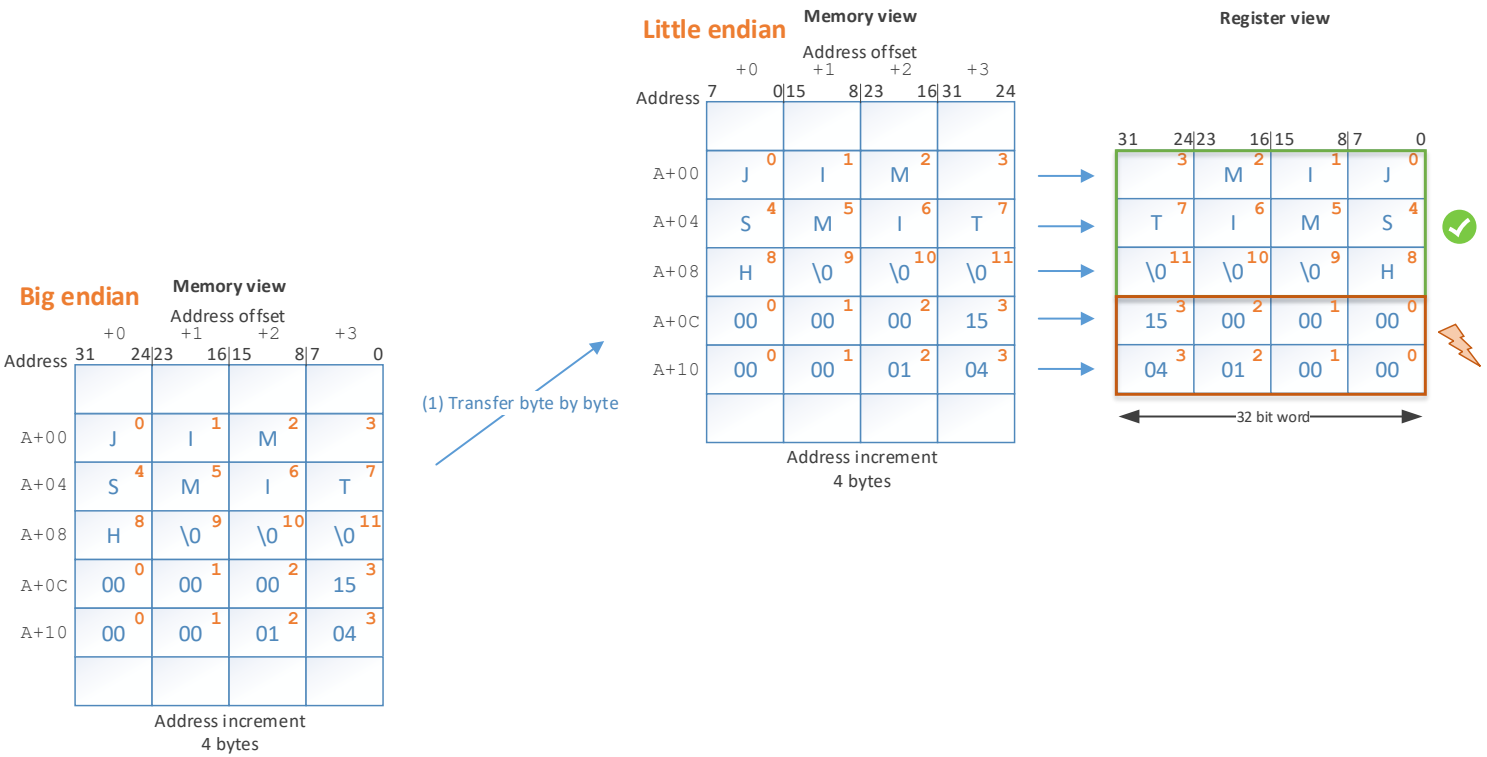

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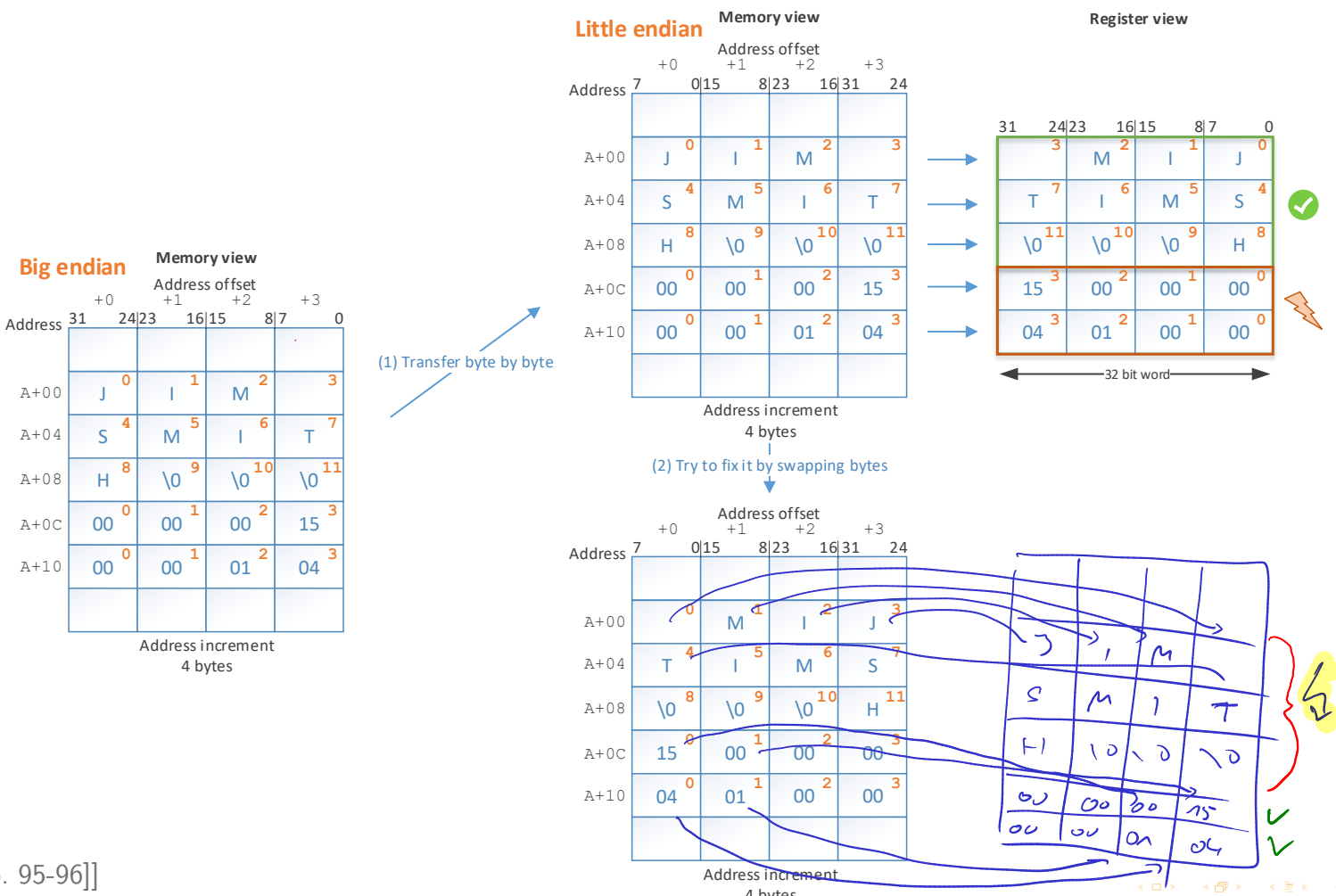

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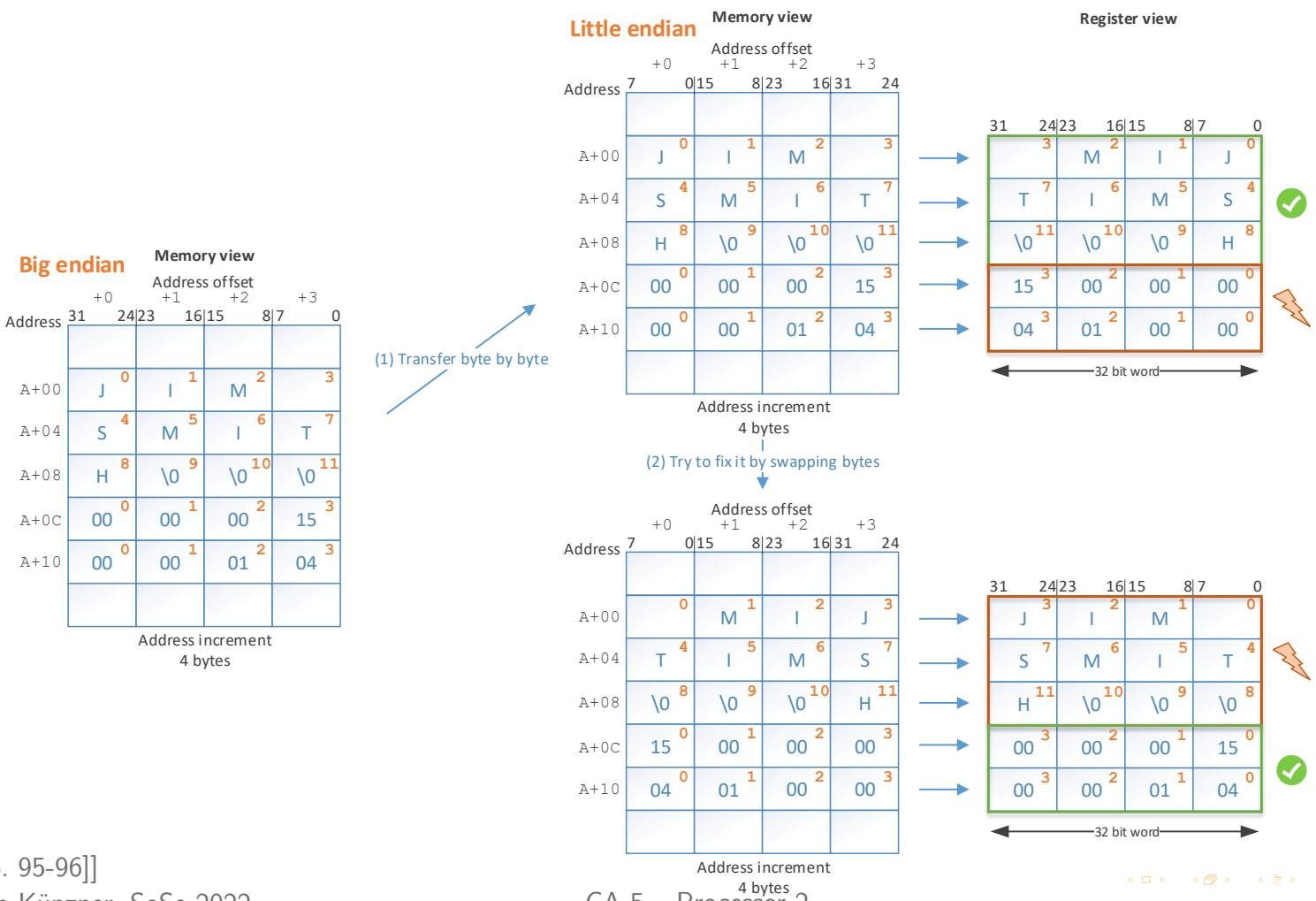

[cmp: [1, p. 95-96]]

Endianness - problem

Problem can occur if

- Different data types are mixed: numbers, strings, or other data types
- Data type consists of more than one byte (multi-byte word, ≥ 2)
- Data are transferred between BE/LE systems

No problem occurs if

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No problem occurs if

- Single-byte data is transferred byte by byte (e.g. ASCII)
- Data is transferred within same endianness (LE -> LE, BE -> BE)

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Endianness - conclusion

Without the knowledge about the data types and the endianness, a transfer between BE/LE systems is not feasible.

Tanenbaum: „*There is no easy solution to this*" [1, p. 96]

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Endianness - possible solutions

Possible solution

- **Know** the endianness (e.g. **meta data!**)
- **Transfer** byte by byte (no problem for single-byte data)
- If endianness is different and a multi-byte word is transferred: additionally **swap** the bytes

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Endianness - solutions

Some examples:

- Network order: always BE
- Java: always BE; for transfer with others, `ByteOrder` can be set
- Unicode UTF-16/32: uses a BOM (byte order mark)
- TIF files: BE/LE identifier in header
- RPC (remote procedure call): marshalling (data as byte stream) solves the problem by using meta data

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Summary and outlook

Summary

- Endianness
- Examples
- Usage
- Transfer
- Solutions

Outlook

- Processor registers
- Processor examples
- Addressing modes

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