Efficient linking

- In network processing, it is a key methodology to reduce the network load of data stream systems.
- Modules and runtime linking provide an efficient and flexible way to distribute data stream operators in WSNs.
- Operators, such as an aggregate operator, have state.
- Nodes may experience overload or degradation.
- Data stream operators must be moved to other nodes.
- Stateful migration allows to preserve state collected over days or weeks.

Steps of migration:
1. The module is informed about the migration. It can release unneeded or local system resources (e.g., files).
2. The thread is stopped.
3. The memory sections are serialized together with their old addresses.
4. The serialized data is sent to the target node.
5. The data is deserialized and memory is allocated from the heap.
6. Using the old section addresses all pointers are adjusted to the new placement of the section.
7. The thread is continued and informed about successful migration.

Migrating modules from one node to another

Switching between nodes

Scenario

Motivation

Sample aggregate module

```
<Program section>
Data section
Pointer section
<Heap>
```

Relocations are inlined using 0x05 as escape character.

Data can be processed as stream

The value following the escape character maps to:
1. 0x05, for the value of 0 (unescape)
2. entries in the address index
3. entries in the address index having an offset. The offset is saved in the next data word.
4. the different memory sections of the module (e.g., program section)

The address index is built by looking up the list of used symbols in the kernel’s symbol table.

Symbols are compressed by sorting them alphabetically and saving the number of characters shared with the previous symbol.

Programming model

Steps of migration:
1. The module is informed about the migration. It can release unneeded or local system resources (e.g., files).
2. The thread is stopped.
3. The memory sections are serialized together with their old addresses.
4. The serialized data is sent to the target node.
5. The thread is continued and informed about successful migration.

Pointers are transparently adjusted to the new placement of memory.

Special malloc and free functions allow migration of memory allocated from heap.

(Pointers in heap memory must be registered with the system.)

```
#include <stdio.h>

int main() {
    int *p = malloc(100);  // Allocate memory
    free(p);  // Free memory
    p = realloc(p, 200);  // Reallocate memory
    p[0] = 10;  // Set value
    p[10] = 20;  // Set value
    printf(“%d
”, p[0]);  // Print value
}  // End of the main function.
```

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Stateful migration allows to preserve state collected over days or weeks.