DEFINITION OF THE TERM

SOCKET PRIMITIVE

IN DISTRIBUTED SYSTEMS

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Abstract

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1   INTRODUCTION

During my work on a technical report I came across the term *Socket Primitive* which was a heavily used term when describing operations with the Transmission Control Protocol / Internet Protocol (TCP/IP) (Tanenbaum & Steen, 2007, p. 141, ch. 4.3.1):

> [...] A socket forms an abstraction over the actual communication end point that is used by the local operating system for a specific transport protocol. In the following text, we concentrate on the socket primitives for TCP, which are shown in Fig. 4-14. [...]

Inevitably the question came up what exactly the term *Socket Primitive* defines? With this technical report, I will first clarify what a *socket* is and what *primitive* means in computer science. Furthermore, I will describe the term *socket primitive* with examples and more detail and define the term.

I also would like to give special thanks to Maarten van Steen who wrote me some more clarification details in the beginning of my research.

Please keep in mind that although I am writing in a more abstract and general way about *socket primitives*, it is always considered to operate with a UNIX Operating System (OS).

1.1   SOCKET

A socket is a communication end point of a computer system. Whenever two computer systems shall communicate with each other, a connection between those systems has to be established by using interconnected sockets (Tanenbaum & Wetherall, 2011, p. 553, ch. 6.5.2).

A socket is always considered to be used associated with a protocol that implements a model of communication. Inter-Process Communication (IPC) will only be successful when both processes use the same protocol. Common protocols are the User Datagram Protocol (UDP) or TCP/IP for example. The used protocol determines what low-level mechanism is used to transmit and receive data (Loosemore *et al.*, 2015, p. 427 - 427, ch. 16).

1.2   PRIMITIVE

1.2.1   MEANING IN COMPUTER SCIENCE

In computer science, the word *primitive* is often used to name an instruction which represents a self-contained unit on the current abstraction level. This also means that there is probably no need for further description of what this

instruction is composed of rather to describe the semantic, logic or functionality the *primitive* introduces.

For example: The GNU C Reference Manual uses the term *Primitive Data Types* to describe the built-in data types in the programming language C (Rothwell & Youngman, 2015, p. 8, ch. 2). The following table shows a selection of primitive data types of a C language, their characteristics and the memory allocation on 64-bit systems. Please see Appendix A for the implementation:

Primitive	Stores	Memory Allocation
char	ASCII characters	1 byte
int	integers	4 byte
float	floating point real numbers	4 byte
double	double precision floating point real numbers	8 byte

As long as a programmer knows what each built-in *Primitive Data Type* represents and how to use it, he must not necessarily know what assembly code the compiler is generating to write code in a high level language. On the contrary, a compiler builder has to.

1.2.2 Meaning in Linguistic Science

The *Oxford Advanced Learners Dictionary* has no definition of the word *primitive* that fits for the use in computer science (A S Hornby, 2005, p. 1197). Nevertheless, the online version `http://www.oxfordlearnersdictionaries.com` offers an additional word origin (Original URL: `http://www.oxfordlearnersdictionaries.com/definition/english/primitive_1?q=primitive`):

> late Middle English (in the sense 'original, not derivative'): from Old French primitif, -ive, from Latin primitivus 'first of its kind', from primus 'first'.

The important part is the late Middle English origin in the sense 'original, not derivative'. As described above, a *primitive data type* has different storing characteristics. In Object-oriented programming (OOP) With those *primitive data types*

2 TCP/IP Socket Primitives

As already mentioned above (chapter 1.1) a socket always operates with a associated protocol. For the programmer of a high level programming language, the protocol specifies the interface to operate with the socket.

The following table lists the most common TCP/IP socket primitives with a short description (Anupama, 2007):

Primitive	Service description
Socket	creates a new socket e.g. communication end point
Bind	associates a local address with a socket
Listen	allows to accept new incoming connections to a socket
Accept	blocks until a connection request
Connect	connects to a socket
Send	sends a message to a socket
Receive	reads a message from a socket
Close	aborts a connection

Figure 2 describes the TCP/IP socket primitives (Tanenbaum & Steen, 2007, p. 142, ch. 4.3.1).

The following definition of the function *send()* is the implementation of the socket primitive *Send* by the GNU C Library (Loosemore *et al.*, 2015, p. 457, ch. 16.9.5.1):

```
ssize_t send(   int socket,
                const void *buffer,
                size_t size,
                int flags)
```

A short description for the parameters:

- socket: The socket file descriptor.

- buffer: Memory address to the data which shall be send.

- size: The size in bytes of the data that shall be send.

- flags: Additional information for the send instruction (Loosemore *et al.*, 2015, p. 459, ch. 16.9.5.3)

The function returns the number of bytes which have been transmitted or -1 if there occurred any error. For more detailed information reading the referenced GNU C Library Reference Manual (Loosemore *et al.*, 2015) on page 457 in chapter 16.9.5.1 is recommended.

The *send()* function is called by the application in user mode which will then call a number of other functions in kernel mode. More detailed, the *send()* function is called in the process that runs in user mode. Afterwards, functions in the socket layer, protocol layer and interface layer are called in kernel mode (Anupama, 2007, p. 2, 16). This implicitly means that even if the interface for sending a message to a socket is relatively easy to use, the actual call stack and possible errors introduces another level of complexity in application logic. But as long as the programmer does not want to treat every possible occurring

error he has not to understand how the *send()* function actually performs the desired instruction but instead is able to completely rely on its provided functionality.

It is also important to mention that this was an example of how the *Send* primitive could be defined as a function. Other C libraries can differ in their definition and provided functionality not to mention other programming languages.

3 DEFINITION

Now that the term *socket primitive* is more clarified, the following definition of primitives by Andrew S. Tanenbaum gives a very good summary (Tanenbaum & Wetherall, 2011, p. 38, ch. 1.3.4):

> A service is formally specified by a set of primitives (operations) available to user processes to access the service. These primitives tell the service to perform some action or report on an action taken by a peer entity. If the protocol stack is located in the operating system, as it often is, the primitives are normally system calls. These calls cause a trap to kernel mode, which then turns control of the machine over to the operating system to send the necessary packets.

The following is the working definition of a *socket primitive*:

> *A socket primitive is a socket related function that is provided by various standard libraries for various high-level programming languages. It provides an interface for calling operating system specific instructions. Therefore, a 'socket primitive' is called primitive because it is the lowest level interface for a programmer who is writing in a high level programming language to operate with sockets.*

A   Primitive Data Types in C++

```cpp
1  #include <iostream>
2
3  /**
4   * Prints the size of the transferred value in bytes as follows:
5   *
6   * Size of 'type_name': X byte
7   *
8   * Where X is the size that is returned by the function sizeof(T).
9   *
10  * @param    type_name        The name of the type.
11  */
12 template <typename T>
13 void print_size(std::string type_name)
14 {
15     std::cout << "Size of " << type_name << ": " << sizeof(T) << "
           byte" << std::endl;
16 }
17
18 /**
19  * Prints out the following integer types:
20  *
21  * - signed char
22  * - unsigned char
23  * - char
24  * - short
25  * - short int
26  * - unsigned short int
27  * - int
28  * - unsigned int
29  * - long int
30  * - unsigned long int
31  * - long long int
32  * - unsigned long long int
33  */
34 void print_integer_types()
35 {
36     print_size<signed char>         ("signed char");
37     print_size<unsigned char>       ("unsigned char");
38     print_size<char>                ("char");
39     print_size<short>               ("short");
40     print_size<short int>           ("short int");
41     print_size<unsigned short int>  ("unsigned short int");
42     print_size<int>                 ("int");
43     print_size<unsigned int>        ("unsigned int");
44     print_size<long int>            ("long int");
45     print_size<unsigned long int>   ("unsigned long int");
46     print_size<long long int>       ("long long int");
47     print_size<unsigned long long int> ("unsigned long long int");
48 }
49
50 /**
51  * Prints out the following real number types:
52  *
53  * - float
54  * - double
```

```cpp
55  * - long double
56  */
57 void print_real_number_types()
58 {
59      print_size<float>       ("float");
60      print_size<double>      ("double");
61      print_size<long double> ("long double");
62 }
63
64 /**
65  * This application prints all listed primitive data types of the
66  * GNU C Reference Manual [1] excluding the complex number types
67  * with information on their allocated memory:
68  *
69  * Integer Types:
70  * - signed char
71  * - unsigned char
72  * - char
73  * - short
74  * - short int
75  * - unsigned short int
76  * - int
77  * - unsigned int
78  * - long int
79  * - unsigned long int
80  * - long long int
81  * - unsigned long long int
82  *
83  * Real Number Types:
84  * - float
85  * - double
86  * - long double
87  *
88  * [1] Rothwell, Trevis, & Youngman, James. 2015. The GNU C
          Reference Manual.
89  * http://www.gnu.org/software/gnu-c-manual/gnu-c-manual.pdf . Free
          Software
90  * Foundation, Inc. [Online. Accessed 1st July 2015].
91  *
92  * @author Florian Willich
93  */
94 int main()
95 {
96      print_integer_types();
97      print_real_number_types();
98
99      return 0;
100 };
```

Acronyms

ASCII American Standard Code for Information Interchange. 2

IPC Inter-Process Communication. 1

OOP Object-oriented programming. 2

OS Operating System. 1

TCP/IP Transmission Control Protocol / Internet Protocol. 1, 2, 3

UDP User Datagram Protocol. 1

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