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Draft
Standard for Prefixes for Binary Multiples

Sponsored by the
Standards Coordinating Committee on Quantities, Units, and Letter Symbols (SCC14)
of the
IEEE Standards Association

Introduction

(This introduction is not part of IEEE P1541, *Standard for Prefixes for Binary Multiples*.)

Modern computers use binary logic for computation and addressing, and binary logic inevitably leads to addresses expressed in binary arithmetic. The size of such an address space is inevitably a power of two. Thus, when computer memories and disks were tiny (in terms of capacity), it became common practice to use "kilo" as a prefix denoting multiplication by 1024 (= 2^{10}). In the 1960s and 1970s this created no problem because there is not much difference between 1000 and 1024, and within the community of persons who used computers everybody understood what was meant. Thus decimal prefixes came to be applied on the grounds that it would have been senseless, in the computer field, to interpret them as anything other than binary multiples, *i.e.*, it would have seemed illogical to size a small memory in multiples of 1000 when the size of the address space was 1024. As the capacity of memories and disks has grown larger, the issue of correspondence with the size of the address space became less important than the issue of total capacity requirements. In addition, the disparity between binary and decimal multiples is larger with the larger prefixes. Data storage specialists now work with terabytes. If one purchases a terabyte of storage, can one store 10^{12} bytes or 2^{40} bytes? The difference is roughly 10 %.

Personal computers have become ubiquitous in the 21st century, and the use of decimal prefixes where binary multiplication is intended causes real confusion. Most computer users today are not specialists. They know that a kilometer is 1000 meters, and, having no familiarity with powers of 2, assume that a kilobyte is 1000 bytes. The result is confusion and occasional misunderstanding. This IEEE standard defines new prefixes for binary multiples and thereby makes precise and unambiguous communication possible. A similar standard [B1] has already been adopted by the International Electrotechnical Commission.

At the time this recommended practice was completed, the Prefixes for Binary Multiples Working Group had the following membership:

James R. Frysinger, *Chair*

Gordon Aubrecht	Stan Jakuba	Ralph Showers
Bruce B. Barrow	Joseph Langenstein	Barry N. Taylor
Stanley L. Ehrlich	James W. Moore	Lorelle Young
David Goldman (deceased)	John Scott	Allan Zuckerwar

The following members of the balloting group voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

(to be supplied by IEEE)

Contents

Draft Standard for Prefixes for Binary Multiples

1. Overview

This standard is divided into four clauses. Clause 1 states the scope and purpose of the standard. Clause 2 quotes relevant standard definitions. Clause 3 defines the prefixes for binary multiples. Clause 4 provides principles for the application of these prefixes.

1.1 Scope

This standard defines names and letter symbols for prefixes that denote multiplication of a unit by the binary multiplier 2^{10n}, where n = 1,2,3,4,5, or 6. Although the prefixes may be used with all units, in all fields where multiplication by a binary multiplier is found to be appropriate, their primary use is in the field of information technology. The prefixes given here have also been adopted by the International Electrotechnical Commission [B2].[1]

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1.2 Purpose

In recent years confusion has resulted from the fact that the SI prefixes-kilo, mega, giga, etc. -have been used sometimes with their correct meaning as decimal multipliers, and sometimes with a special meaning as binary multipliers. The purpose of this standard is to establish prefixes for binary multiples in order to make precise and unambiguous communication possible, especially within the fields of data processing and information systems.

2. Definitions

For the purposes of this recommended practice, the following terms and definitions, taken from reference [B3], apply. IEEE 100,The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition should be referenced for terms not defined in this clause.

2.1 byte (B): a group of adjacent binary digits operated on as a unit; usually eight bits.

2.3 octet (o): a byte composed of eight bits.

3. Prefixes for binary multiples

The prefixes given in Table 1 shall be used to indicate multiplication by 2^{10n}, where n = 1,2,3,4,5, or 6.

[1]The numbers in brackets correspond to those of the bibliography in Annex A.

Table 1—Prefixes

Factor	Name	Symbol	Origin	Related SI Prefixes		Examples
2^{10}	kibi	Ki	kilobinary: (2^{10})	kilo: (10^3)	k	Kib = 1.024 kb
2^{20}	mebi	Mi	megabinary: $(2^{10})^2$	mega: $(10^3)^2$	M	MiB ≈ 1.0486 MB
2^{30}	gibi	Gi	gigabinary: $(2^{10})^3$	giga: $(10^3)^3$	G	Gio ≈ 1.0737 Go
2^{40}	tebi	Ti	terabinary: $(2^{10})^4$	tera: $(10^3)^4$	T	Tib ≈ 1.0995 Tb
2^{50}	pebi	Pi	petabinary: $(2^{10})^5$	peta: $(10^3)^5$	P	PiB ≈ 1.1259 PB
2^{60}	exbi	Ei	exabinary: $(2^{10})^6$	exa: $(10^3)^6$	E	Eio ≈ 1.1529 Eo

4. Principles of usage

4.1 The SI prefixes

The SI prefixes shall not be used to denote multiplication by powers of two.

4.2 Application of the prefixes for binary multiples

This standard is prepared with two goals in mind: (1) to preserve the SI prefixes as unambiguous decimal multipliers, and (2) to provide alternative prefixes for those cases where binary multipliers are needed. The first goal affects the general public, the wide audience of technical and non-technical persons who use computers without much concern for their construction or inner working. These persons will normally interpret kilo, mega, *etc*., in their proper decimal sense. The second goal speaks to specialists—the prefixes for binary multiples make it possible for persons who work in the information sciences to communicate with precision. The following two examples illustrate some of the current confusion.

Example 1: The common 90 mm (nominal 3.5 inch) diskette, as formatted for PC use, is usually advertised as containing 1.44 megabytes. It is actually formatted for 1440 kibibytes, and the "mega" in this application is neither a proper SI prefix nor a binary prefix. The resulting hybrid "megabyte" is equal to $10^3 \cdot 2^{10}$ bytes.

Example 2: The following "Frequently Asked Question" appears in an instruction manual widely distributed in 1999:

> *Q:* The formatted capacity of my hard drive seems smaller than what was ordered. Why?
>
> *A:* Your operating system assumes that 1 MB equals 1 048 576 bytes. Drive manufacturers consider 1 MB as equal to 1 000 000 bytes. Thus if the drive is advertised as 6.4 gigabytes (6 400 000 000 bytes) the operating system sees it as approximately 6.1 GB. [(6 400 000 000)/(1 048 576 000) = 6.1035...].

Note that in this example the PC vendor creates a hybrid "gigabyte" that is equal to $10^3 \cdot 2^{20}$ bytes.

The first example represents more of a curiosity than a real problem, for the difference between the advertised "1.44 MB" and the more accurate 1.47 MB is of little practical importance. The second example, however, calls attention to an area where there has been real misunderstanding between buyers and sellers of hard drives. The difference between a gigabyte and a gibibyte is approximately 7.5%.

Annex A

Bibliography

[B1] ANSI/IEEE Std 260.1-2002, American National Standard Letter Symbols for Units of Measurement (SI Units, Customary Inch-Pound Units, and Certain Other Units).

[B2] IEC 60027-2, Letter symbols to be used in electrical technology, Part 2: Telecommunications and electronics, Amendment 2, 1999-01.

[B3] IEEE Std 100-1996, The IEEE Standard Dictionary of Electrical and Electronics Terms.

[B4] IEEE/ASTM SI 10-2002, Standard for Use of the International System of Units (SI): The Modern Metric System.