Abstract

This paper first discusses a vision for a future replacement for the `<limits>` header and assorted other related facilities that are today scattered among such other headers as `<cfloat>`, `<climits>`, and `<cmath>`. The paper then proposes a new `<num_traits>` header to consolidate and subsume all these facilities.

[Why are numbers beautiful?] It’s like asking why is Ludwig van Beethoven’s Ninth Symphony beautiful. If you don’t see why, someone can’t tell you. I know numbers are beautiful. If they aren’t beautiful, nothing is.

— PAUL ERDŐS

Two of the most famous Baghdadi scholars, the philosopher Al-Kindi and the mathematician Al-Khwarizmi, were certainly the most influential in transmitting Hindu numerals to the Muslim world. Both wrote books on the subject [that were] translated into Latin and transmitted to the West, thus introducing Europeans to the decimal system, which was known in the Middle Ages only as Arabic numerals. But it would be many centuries before it was widely accepted in Europe. One reason for this was sociological: decimal numbers were considered for a long time as symbols of the evil Muslim foe.

— JAMEEL SADIK “JIM” AL-KHALILI

One of the main causes of the fall of the Roman Empire was that, lacking zero, they had no way to indicate successful termination of their C programs.

— ROBERT FIRTH

1 Introduction

The header `<limits>` provides `numeric_limits<>` and enums `float_round_style` and `float_denorm_style`. The design of this header long predates our modern understanding of traits programming. For example, Meredith and Oram point out in [N2591] that:

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numeric_limits is a monolithic class template designed for user-extension through template specialization. Unfortunately this means [that] any attempt to extend the interface by the standard renders all existing user specializations invalid. This problem could have been avoided if each trait in numeric_limits had been declared as its own template, such as with the type traits library.

That paper then proposes to "Break the monolithic numeric_limits class template apart into a lot of individual trait templates, so that new traits can be added easily." We certainly agree with this general direction. Moreover, we today have far better tools for accommodating such cleanup than we had at the time (2008). We have:

- constexpr and type traits in C++11,
- variable templates and improved type traits in C++14,
- constexpr if statements in C++17, and
- requires-clauses and requires-expressions in the Concepts-Lite TS.

We should also consider breaking changes as we transition to an updated Standard Library. Although our proposal would allow keeping the existing numeric_limits, we believe it is a better idea to excise it (and other overlapping features) to avoid maintaining the same information in several forms. Therefore, our proposal will unify and subsume all these and other related facilities.

2 Desiderata

- Create individual numeric traits from the facilities today provided via <limits>. Collect these new individual traits into a new header, <num_traits>, ensuring that each can be user-specialized.
- Identify and excise other library facilities (e.g., from C headers and their C++ analogs) that duplicate these capabilities.
- Identify other numeric library facilities that are traits-like in nature. Provide these facilities (possibly in a different form) in the new <num_traits> header, then excise them from their current location.
- In all cases, ensure that no significant capabilities are lost in the process.
- No empty header (e.g., <limits>) will be retained.

3 Classifying <limits>

Today’s numeric_limits has 32 members, of several kinds. Some describe characteristics of the given parameter T, some provide special values of T, etc. All have specified default values, generally T{} or false. For purposes of exposition, we will classify the members as follows:

1. Applicability:
   - is_specialized
2. Distinguished values:
   - denorm_min()  epsilon()  infinity()  lowest()  max()  min()
   - quiet_NaN()  round_error()  signaling_NaN
3. Value introspection:
   - has_infinity  has_quiet_NaN  has_signaling_NaN
4. Descriptive characteristics:
   - digits  digits10  max_digits10  max_exponent  max_exponent10
   - min_exponent  min_exponent10  radix
5. Behaviorial characteristics
   • has_denorm  • has_denorm_loss  • is_bounded  • is_exact  • is_iec559
   • is_integer  • is_modulo  • is_signed  • round_style  • tinyness_before
   • traps

We will discuss our proposal one classification at a time.

4 Applicability

This classification encompasses but a single member: is_specialized. We propose no replacement for this member. To compensate, we will propose, below, that our individual traits be SFINAE-friendly, and will also propose a few general-purpose facilities for detecting values' presence/absence.

5 Distinguished values

This classification encompasses the following numeric_limits members: denorm_min(), epsilon(), infinity(), lowest(), max(), min(), quiet_NaN(), round_error(), and signaling_NaN(). With T as the template argument, each is specified as a member function returning a value of type remove_cv_t<T>.

Given the current state of constexpr technology, we believe it is no longer necessary that these be functions. Therefore, we propose that each of these become independent constexpr variable templates. We also propose that, as independent traits, these be renamed with a num_ prefix:

   • num_denorm_min  • num_epsilon  • num_infinity
   • num_lowest  • num_max  • num_quiet_NaN
   • num_min  • num_round_error  • num_signaling_NaN

We now show a sample implementation for a single numeric trait.\footnote{Using a recent development version of gcc, we have implemented all the numeric traits in the present proposal. Because all these traits follow a similar coding pattern, we opted to show only one in the interest of at least some brevity.}

5.1 Exposition-only helpers

We first present a behind-the-scenes implementation of the trait intended for use with only cv-unqualified types. The primary template is defined to provide no result so as to be SFINAE-friendly, while the specializations use gcc-provided intrinsics to provide the appropriate results, if any, for floating-point types.

\begin{verbatim}
1 template< class T > struct infinity_unqual { }

3 #ifdef __FLT_HAS_INFINITY__
4     template<> struct infinity_unqual<float>
5       { static constexpr float value = __builtin_huge_valf(); }; }
6 #endif

8 #ifdef __DBL_HAS_INFINITY__
9     template<> struct infinity_unqual<double>
10       { static constexpr double value = __builtin_huge_val(); }; }
11 #endif
\end{verbatim}
#ifdef __LDBL_HAS_INFINITY__
    template<> struct infinity_unqual<long double>
    { static constexpr long double value = __builtin_huge_vall(); };
#endif

5.2 Numeric trait
Here is an implementation for the trait itself. Note that it is crafted to accommodate user-provided specializations, if any, and to employ facility inheritance, otherwise.\(^2\)

    template< class T >
    struct num_infinity : infinity_unqual<T> { };

    template< class T >
    requires is_const_v<T> or is_volatile_v<T>
    struct num_infinity<T> : num_infinity< remove_cv_t<T> > { };

5.3 Trait's value
Consistent with C++17’s \_v-suffixed value extraction for type traits and the like, we provide a constrained variable template for the same purpose. If the trait provides no value for a given template argument, the constraint will ensure that the program will be ill-formed. (See §6 for a general means to determine whether such a value exists for a given type.)

    template< class T >
    requires requires { num_infinity<T>::value; }
    constexpr auto num_infinity_v = num_infinity<T>::value;

5.4 Backward compatibility
We use a similar technique to provide overloaded function templates to allow value extraction in all cases. The returned value will be the value of the trait, if it exists, or else a user-provided value. (If the user fails to provide such a value, the default value specified for \texttt{numeric\_limits::infinity()} will be used.)

    template< class T >
    constexpr auto num_infinity_or( T def = T() ) noexcept
    { return def; }

    template< class T >
    requires requires { num_infinity<T>::value; }
    constexpr auto num_infinity_or( T = T() ) noexcept
    { return num_infinity<T>::value; }

We note in passing that adoption of our paper \cite{P0266R1}, combined with C++17’s \texttt{constexpr if} control structure, would allow a somewhat more straightforward implementation:

\(^2\)Strictly speaking, no inheritance is needed to implement this specific trait, but this pattern can be used to implement all of the proposed traits. We therefore also follow the pattern here for exposition purposes.
template< class T >
constexpr auto num_infinity_or( T def = T() ) noexcept
{
    if constexpr( requires { num_infinity<T>::value; } )
        return num_infinity<T>::value;
    else
        return def;
}

However, we will not propose such a function to accompany each trait. Instead, we propose a
single, more general mechanism to guarantee obtaining a value, independent of whether the trait
is defined for a given type:

template< template< class > class Trait, class T, class R = T >
constexpr R
value_or( R def = R() ) noexcept
{ return def; }

//
template< template< class > class Trait, class T, class R = T >
requires requires { Trait<T>::value; }
constexpr R
value_or( R = R() ) noexcept
{ return Trait<T>::value; }

Such a utility permits numeric_limits-style backwards compatibility, as follows:

costexpr T
infinity( ) noexcept
{ return value_or<num_infinity, T>(); }

6 Value introspection

This classification encompasses the bool-valued numeric_limits members has_inf, has_ quiet_NaN, and has_signaling_NaN. These are designed to report on the meaningful existence
of other members. For example, numeric_limits<>::has_infinity is specified as “True if the
type has a representation for positive infinity” ([numeric.limits.members]/33).

We believe these traits are neither necessary nor sufficient. Given that our traits are designed
to be extensible to user-defined numeric types, is seems useful to have, instead, a more general
mechanism to query the existence of any trait for any numeric type. Therefore, we do not propose
any one-for-one replacement for the introspective members listed above. Instead, we propose
value_exists, a single, more general facility, designed to be applicable to all numeric traits and
all numeric types.

We see three possible means to provide this value_exists.

1. Wait for a proposal from the introspection study group SG7.
2. Assume adoption of our paper [P0266R1].
3. Use C++17-style metaprogramming, possibly in combination with Concepts Lite.

6.1 Implementations

We have implemented and tested value_exists as follows:
template< template< class > class Trait, class T >
constexpr bool
value_exists = false;

//
template< template< class > class Trait, class T >
requires requires { Trait<T>::value; }
constexpr bool
value_exists<Trait, T> = true;

Assuming adoption of our paper [P0266R1], a simpler implementation of \texttt{value\_exists} becomes possible:

\begin{verbatim}
template< template< class > class Trait, class T >
constexpr bool
value_exists = requires { Trait<T>::value; };
\end{verbatim}

6.2 Uses for \texttt{value\_exists}

No matter how \texttt{value\_exists} is provided, here is a typical application, implementing the aforementioned \texttt{has\_infinity}:

\begin{verbatim}
template< class T >
constexpr bool
has_infinity = value_exists<num\_infinity, T>;
\end{verbatim}

As another use for \texttt{value\_exists}, here is how it can be applied in C++17 to obtain a more straightforward implementation of \texttt{value\_or}, described in §5 above:

\begin{verbatim}
template< template< class > class Trait, class T, class R = T >
constexpr R
value\_or( R def = R() ) noexcept
{
  if constexpr( value_exists<Trait, T> )
    return Trait<T>::value;
  else
    return def;
}
\end{verbatim}

Finally, we note that adoption of our paper [P0266R1] could actually obviate \texttt{value\_exists}. To illustrate this, here is an alternate implementation of our first use case\textsuperscript{3}:

\begin{verbatim}
template< class T >
constexpr bool
has\_infinity = requires { num\_infinity<T>::value; };
\end{verbatim}

7 Descriptive characteristics

This classification encompasses the following members of \texttt{numeric\_limits}: \texttt{digits}, \texttt{digits10}, \texttt{max\_digits10}, \texttt{max\_exponent}, \texttt{max\_exponent10}, \texttt{min\_exponent}, \texttt{min\_exponent10}, and \texttt{radix}. Each of these is specified as \texttt{int}-valued. We therefore propose to provide these as independent \texttt{constexpr} variable templates. We also propose, as before, that these be renamed with a \texttt{num\_} prefix:

\footnote{Of course, the use case itself could be obviated by analogous reasoning.}
As an example, here is an implementation of the proposed `num_max_exponent` trait. Note that it follows the same coding pattern as presented earlier:

```cpp
1 template< class T > struct max_exponent_unqual { };  
2 //  
3 template<> struct max_exponent_unqual<float>  
4 { static constexpr int value = __FLT_MAX_EXP__; };  
5 //  
6 template<> struct max_exponent_unqual<double>  
7 { static constexpr int value = __DBL_MAX_EXP__; };  
8 //  
9 template<> struct max_exponent_unqual<long double>  
10 { static constexpr int value = __LDBL_MAX_EXP__; };  
11  
12 template< class T >  
13 struct num_max_exponent : max_exponent_unqual<T> { };  
14 //  
15 template< class T >  
16  
17 struct num_max_exponent<T> : num_max_exponent< remove_cv_t<T> > { };  
18  
19 template< class T >  
20  
21 requires requires { num_max_exponent<T>::value; }  
22 constexpr auto  
23 num_max_exponent_v = num_max_exponent<T>::value;
```

### 8 Behavioral characteristics

This classification encompasses the following members of `numeric_limits`: `has_denorm`, `has_denorm_loss`, `is_bounded`, `is_exact`, `is_iec559`, `is_integer`, `is_modulo`, `is_signed`, `round_style`, `tinyness_before`, and `traps`. With two exceptions, these members have type `bool`. The exceptions are `has_denorm` (which has type `float_denorm_style`) and `round_style` (whose type is `float_round_style`).

Rather than propose replacements for these characteristics, we recommend that the numerics study group SG6 first analyze the requirements of recent other standards in this area and make recommendations accordingly. We suggest the documents to be examined include IEEE 754-2008 (also known as ISO/IEC/IEEE 60559:2011) on floating-point, the ISO/IEC 10967 series on language-independent computer arithmetic, the relevant C11 annexes, and other relevant recent work by WG14.

If SG6 declines to undertake this task, our default position will (reluctantly) be to recommend traits that retain the flavor of the existing `numeric_limits` members listed above.

### 9 Effects on other headers

The section explores possible ramifications of our proposal with respect to headers inherited from C. Numerous macros are identified as redundant with our proposal. Given the availability of
C++11’s constexpr, C++14’s variable templates, and C++17’s constexpr if, we believe it is time to reconsider continued support of preprocessor idioms relying on these macros.

9.1 <climits>
This header, inherited from C, consists of macros only. Our proposed traits obviate most of these; the remaining two should go elsewhere. Then support for this header can be deprecated and/or removed outright.

- CHAR_BIT — not a numeric trait; move elsewhere as determined by SG6/LEWG
- [CHAR SCHAR SHRT INT LONG LONGLONG]_MIN — obviated by num_min<>
- MB_LEN_MAX — not a numeric trait; move elsewhere as determined by SG6/LEWG
- [CHAR SCHAR SHRT INT LONG LONGLONG]_MAX — obviated by num_max<>
- [UCHAR USHRT UINT ULONG ULLONGLONG]_MAX — obviated by num_max<>

9.2 <cstdint>
This header, inherited from C, specifies the following macros, among other contents. Each is obviated as shown, and its support should be deprecated and/or removed outright from this header.

- INT_[FAST LEAST][8 16 32 64]_MIN — obviated by num_min<>  
- [U]INT_[FAST LEAST][8 16 32 64]_MAX — obviated by num_max<>  
- INT[MAX PTR]_MIN — obviated by num_min<>  
- [U]INT[MAX PTR]_MAX — obviated by num_max<>  
- [PTRDIFF SIG_ATOMIC WCHAR WINT]_HAS_SUBNORM — to be determined by SG6/LEWG  
- [PTRDIFF SIG_ATOMIC WCHAR WINT]_MIN — obviated by num_min<>  
- [PTRDIFF SIG_ATOMIC WCHAR WINT]_MAX — obviated by num_max<>  
- SIZE_MAX — obviated by num_max<>  

9.3 <cfloat>
This header, inherited from C, consists of macros only. Our proposed traits obviate most of them; we would like to do likewise with the rest so that support for this header can be deprecated and/or removed outright.

- FLT_ROUNDS — to be determined by SG6/LEWG  
- FLT_EVAL_METHOD — to be determined by SG6/LEWG  
- [FLT DBL LDBL]_HAS_SUBNORM — to be determined by SG6/LEWG  
- FLT_RADIX — obviated by num_radix<>  
- [FLT DBL LDBL]_MANT_DIG — obviated by num_digits<>  
- [FLT DBL LDBL]_DECIMAL_DIG — obviated by num_digits10<>  
- DECIMAL_DIG — obviated by num_max_digits10<>  
- [FLT DBL LDBL]_DIG — obviated by num_digits10<>  
- [FLT DBL LDBL]_MIN_EXP — obviated by num_min_exponent<>  
- [FLT DBL LDBL]_MIN_10_EXP — obviated by num_min_exponent10<>  
- [FLT DBL LDBL]_MAX_EXP — obviated by num_max_exponent<>  
- [FLT DBL LDBL]_MAX_10_EXP — obviated by num_max_exponent10<>  
- [FLT DBL LDBL]_MAX — obviated by num_max<>  
- [FLT DBL LDBL]_EPSILON — obviated by num_epsilon<>  
- [FLT DBL LDBL]_MIN — obviated by num_lowest<>  
- [FLT DBL LDBL]_TRUE_MIN — obviated by num_min<>
9.4 <cmath>
This header, inherited from C, specifies the following macros, among other contents. Each is obviated as shown, and its support should be deprecated and/or removed outright from this header.

- HUGE_VAL[F L] — obviated by num_infinity<>?
- INFINITY — obviated by num_infinity<>?
- NAN — obviated by num_quiet_NaN<>?

10 Proposed wording

10.1 For the purposes of SG10 (Feature Testing), no macro seems necessary. As we are proposing an entirely new header, using the standard has-include-expression

```c++
__has_include(<num_traits>)
```

seems sufficient to detect this proposal.

10.2 Remove the entries for <limits>, <climits>, and <cfloat>, and replace them with a (single) entry for <num_traits> in Tables 14 (C++ library headers), 17 (C++ headers for freestanding implementations), and 30 (Language support library summary).

Also remove the <climits> and <cfloat> entries from Table 15 (C++ headers for C library facilities).

10.3 Remove [support.limits] (18.3). Replace it with the following new text.

18.3 Numeric traits

18.3.1 General

This subclause describes components, known as traits, used by C++ programs in connection with numeric types. In addition to some traits of general utility, the subclause specifies traits providing distinguished values and implementation-dependent characteristics of such types.

Not all traits are applicable to all numeric types, but where a trait is applicable, its definition shall provide a value appropriate to the type’s representation. Such values shall be defined so that they are usable as constant expressions. When a trait is instantiated on a cv-qualified type cv T, the trait’s value shall be equal to the value, if any, provided by the specialization on the unqualified type T.

Each non-utility trait specified in this subclause is declared as a class template having the following form:

```cpp
template <class T> struct Trait;
```

Each such Trait shall be specialized, if and as applicable, for each arithmetic type T [basic.fundamental] (3.9.1). In addition, a program may specialize each such Trait as applicable, for any cv-unqualified, non-reference, user-defined type T. In all cases, is_empty_v<Trait<T>> shall be true.

18.3.2 Header <num_traits> synopsis

```cpp
namespace std {
    // [num.traits.util], numeric utility traits:
    template <template <class> class Trait, class T>
```

4All proposed additions and deletions are relative to the post-Oulu Working Draft [N4606]. Drafting and editorial notes are displayed against a gray background.
constexpr bool value_exists = see below;
template <template <class> class Trait, class T, class R = T>
    constexpr R value_or(R def = R()) noexcept;

// [num.traits.val], numeric distinguished value traits:
template <class T> struct num_denorm_min { see below };
template <class T> struct num_epsilon { see below };
template <class T> struct num_infinity { see below };
template <class T> struct num_lowest { see below };
template <class T> struct num_max { see below };
template <class T> struct num_min { see below };
template <class T> struct num_quiet_NaN { see below };
template <class T> struct num_round_error { see below };
template <class T> struct num_signaling_NaN { see below };
template <class T>
    constexpr auto num_denorm_min_v = num_denorm_min<T>::value;
template <class T>
    constexpr auto num_epsilon_v = num_epsilon<T>::value;
template <class T>
    constexpr auto num_infinity_v = num_infinity<T>::value;
template <class T>
    constexpr auto num_lowest_v = num_lowest<T>::value;
template <class T>
    constexpr auto num_max_v = num_max<T>::value;
template <class T>
    constexpr auto num_min_v = num_min<T>::value;
template <class T>
    constexpr auto num_quiet_NaN_v = num_quiet_NaN<T>::value;
template <class T>
    constexpr auto num_round_error_v = num_round_error<T>::value;
template <class T>
    constexpr auto num_signaling_NaN_v = num_signaling_NaN<T>::value;

// [num.traits.char], numeric characteristics traits:
template <class T> struct num_digits { see below };
template <class T> struct num_digits10 { see below };
template <class T> struct num_max_digits10 { see below };
template <class T> struct num_max_exponent { see below };
template <class T> struct num_max_exponent10 { see below };
template <class T> struct num_min_exponent { see below };
template <class T> struct num_min_exponent10 { see below };
template <class T> struct num_radix { see below };
template <class T>
    constexpr auto num_digits_v = num_digits<T>::value;
template <class T>
    constexpr auto num_digits10_v = num_digits10<T>::value;
template <class T>
    constexpr auto num_max_digits10_v = num_max_digits10<T>::value;
template <class T>
    constexpr auto num_max_exponent_v = num_max_exponent<T>::value;
template <class T>
    constexpr auto num_max_exponent10_v = num_max_exponent10<T>::value;
template <class T>
    constexpr auto num_min_exponent_v = num_min_exponent<T>::value;
    constexpr auto num_min_exponent10_v = num_min_exponent10<T>::value;
template <class T>
    constexpr auto num_min_exponent10_v = num_min_exponent10<T>::value;
    template <class T>
    constexpr auto num_radix_v = num_radix<T>::value;
}  

18.3.3 Numeric utility traits

template <template <class> class Trait, class T>
    constexpr bool value_exists = see below;

1 Value: true if Trait<T> has a member named value, and false otherwise.

template <template <class> class Trait, class T, class R = T>
    constexpr R value_or(R def = R()) noexcept;

2 Returns: Trait<T>::value, if value_exists<Trait, T> is true; def, otherwise.

18.3.4 Numeric distinguished value traits

1 Each trait in this subclause shall have a static constexpr T data member named value if
    and only if the trait is applicable to the type T. Such a member, if any, shall be initialized to a
    value as specified below; otherwise, there shall be no member value.

    template <class T> struct num_denorm_min { see below };

2 Value: T's minimum positive denormalized value, if any; otherwise, T's minimum positive
    normalized value, if any.

    template <class T> struct num_epsilon { see below };

3 Value: T(1) - E, where E denotes T's least value greater than 1, if any.

    template <class T> struct num_infinity { see below };

4 Value: T's positive infinity, if any.

    template <class T> struct num_lowest { see below };

5 Value: A finite value x, if any, such that T has no other finite value y where y < x.

    template <class T> struct num_max { see below };

6 Value: A finite value x, if any, such that T has no other finite value y where y > x.

    template <class T> struct num_min { see below };

7 Value: T's minimum positive normalized value, if T supports denormalization; otherwise, the
    same value as num_lowest, if any.

    template <class T> struct num_quiet_NaN { see below };

8 Value: T's quiet “Not a Number” value, if any.

    template <class T> struct num_round_error { see below };

9 Value: T's maximum rounding error, if any.

    template <class T> struct num_signaling_NaN { see below };
10 **Value:** T’s signaling “Not a Number” value, if any.

18.3.5 Numeric characteristics traits [num.traits.char]

1 Each trait in this subclause shall have a static constexpr int data member named `value` if and only if the trait is applicable to the type T. Such a member, if any, shall be initialized to a value as specified below; otherwise, there shall be no member `value`.

```cpp
template <class T> struct num_digits { see below };
```

2 **Value:** The number of `num_radix_v<T>` digits that can be represented without change. If `is_integer_v<T>` is true, this is the number of non-sign bits in the representation; If `is_floating_point_v<T>` is true, this is the number of `num_radix_v<T>` digits in the mantissa.

```cpp
template <class T> struct num_digits10 { see below };
```

3 **Value:** The number of base 10 digits that can be represented without change.

```cpp
template <class T> struct num_max_digits10 { see below };
```

4 **Value:** The number of base 10 digits required to ensure that type T values which differ are always differentiated.

```cpp
template <class T> struct num_max_exponent { see below };
```

5 **Value:** With \( r = \text{num_radix_v<T>} \), the largest positive integer \( i \) such that \( r^{i-1} \) is a representable finite value of type T.

```cpp
template <class T> struct num_max_exponent10 { see below };
```

6 **Value:** The largest positive integer \( i \) such that \( 10^i \) is in the range of representable finite type T values.

```cpp
template <class T> struct num_min_exponent { see below };
```

7 **Value:** With \( r = \text{num_radix_v<T>} \), the minimum negative integer \( i \) such that \( r^{i-1} \) is a representable, normalized (if applicable), finite value of type T.

```cpp
template <class T> struct num_min_exponent10 { see below };
```

8 **Value:** The minimum negative integer \( i \) such that \( 10^i \) is in the range of representable, normalized (if applicable), finite type T values.

```cpp
template <class T> struct num_radix { see below };
```

9 **Value:** The base of the representation. If `is_floating_point_v<T>` is true, this shall refer to the base or radix (often 2) of the exponent representation.

11 **Acknowledgments**

Many thanks to the readers of early drafts of this paper for their thoughtful comments.
12 Bibliography


13 Document history

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