NICE ELKS 2000 proposal
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In 1995, NICE (The Non-Profit International Consortium for Eiffel) adopted the ELKS’95 standard for Eiffel kernel libraries. Since then, and despite the fact it was supposed to be updated each year and although it was considered by many as an imperfect standard, ELKS had not evolved beyond ELKS’95.

In July 1999, Emmanuel Stapf (from ISE) and Dominique Colnet and Olivier Zendra (both from the SmallEiffel team) met in Nancy, France, and worked on a much-needed proposal (limited to ARRAY and STRING) to try and get ELKS evolving a bit. This initial ELKS 2000 draft proposal was then submitted for review to other Eiffel experts, then to a meeting in TOOLS USA.

It is now discussed in the NICE mailing list dedicated to library issues, http://www.egroups.com/group/eiffel-nice-library.

This site gives access to the following resources:

- current_array.html: The current state of the ELKS 2000 proposal for ARRAY.
- current_string.html: The current state of the ELKS 2000 proposal for STRING.
- initial_array.html: The initial ELKS 2000 proposal for ARRAY.
- initial_string.html: The initial ELKS 2000 proposal for STRING.
- changelog.html: The list of changes between the initial and the current ELKS 2000 proposals.

Maintainers: Dominique Colnet and Olivier Zendra.

Last Update: 20 August 1999.
5.12 Class ARRAY (current ELKS2000 status)

[Please don't report broken URLs because this page is still a draft.]

**indexing**

description: "Resizable sequences of values, all of the same type or of a % conforming one, accessible through integer indices in a % contiguous interval"

**class interface**

ARRAY [G]

**creation**

```make (minindex, maxindex: INTEGER)
-- Allocate array; set index interval to
-- minindex .. maxindex; set all values to default.
-- (Make array empty if minindex > maxindex.)
require
valid_indices: (minindex <= maxindex) or (maxindex = minindex - 1)
ensure
lower_set: lower = minindex
upper_set: upper = maxindex
-- array_set: for i in minindex..maxindex, item(i) = default item
```

```make_from_array (a: ARRAY [G])
-- Initialize from the items of a.
-- (Useful in proper descendants of class ARRAY,
-- to initialize an array-like object from a manifest array.)
require
valid_array: a /= Void
```

**feature** -- Initialization

```make (minindex, maxindex: INTEGER)
-- Set index interval to minindex .. maxindex;
-- reallocate if necessary; set all values to default.
-- (Make array empty if minindex > maxindex.)
require
valid_indices: (minindex <= maxindex) or (maxindex = minindex - 1)
ensure
lower_set: lower = minindex
upper_set: upper = maxindex
-- array_set: for i in minindex..maxindex, item(i) = default item
```

```make_from_array (a: ARRAY [G])
-- Initialize from the items of a; reallocate if
-- necessary. (Useful in proper descendants of
-- class ARRAY, to initialize an array-like object
-- from a manifest array.)
require
valid_array: a /= Void
```

**feature** -- Access

```first: like item
-- First element
require
not_empty: not is_empty
ensure
definition: Result = item(lower)
```

```has (v: like item): BOOLEAN
-- Does Current contain v?
-- Use equal as comparison operator.
ensure
definition: Result = valid_index(index_of(v));```
index_of (v: like item): INTEGER
-- Index of first occurrence of v
-- Use equal as comparison operator.
-- Upper + 1 if not found
ensure
not_found: (Result = upper + 1) = not has(v);
found: has(v) implies equal(v,item(Result));

infix "@", item (i: INTEGER): G
-- Entry at index i
require
good_key: valid_index (i)

last: like item
-- Last element
require
not_empty: not is_empty
ensure
definition: Result = item (upper)

reverse_index_of (v: like item): INTEGER
-- Index of last occurrence of v?
-- Use equal as comparison operator.
-- Lower - 1 if not found
ensure
not_found: (Result = upper + 1) = not has(v);
found: has(v) implies equal(v,item(Result));

feature -- Measurement

capacity: INTEGER
-- Number of elements that Current can currently contain in the internal storage.
-- Automatically updated when resizing is needed. Useful for fine tuning.

count: INTEGER
-- Number of valid indices
ensure
definition: Result = upper - lower + 1;

lower: INTEGER
-- Minimum valid index

occurrences (v: like item): INTEGER
-- Number of times v appears in Current.
-- Use equal as comparison operator.
ensure
non_negative_occurrences: Result >= 0

upper: INTEGER
-- Maximum valid index

feature -- Comparison

is_equal (other: like Current): BOOLEAN
-- Do both arrays have same lower, upper and
-- items (compared with is_equal)?
-- (Redefined from GENERAL.)

feature -- Status report

is_empty: BOOLEAN
-- Is array empty?
ensure
definition: Result = (count = 0)

valid_index (i: INTEGER): BOOLEAN
-- Is i within the bounds of the array?
ensure
definition: lower <= i and i <= upper

feature -- Element change

add (v: like item; i: INTEGER)
-- Insert v at index i, shifting elements between ranks i and upper rightwards.
require
    valid_insertion_index: \text{lower} \leq i \leq \text{upper} + 1
ensure
    inserted: \text{item} (i) = v;
    same_lower: \text{lower} = \text{old lower};
    higher_upper: \text{upper} = \text{old upper} + 1

add\_first (v: \text{like item})
    -- Insert \(v\) at index \text{lower}, shifting all elements rightwards.
ensure
    inserted: first = v;
    same_lower: \text{lower} = \text{old lower};
    higher_upper: \text{upper} = \text{old upper} + 1

add\_last (v: \text{like item})
    -- Append \(v\) at end.
ensure
    inserted: last = v;
    same_lower: \text{lower} = \text{old lower};
    higher_upper: \text{upper} = \text{old upper} + 1

force (v: \text{like item}; i: \text{INTEGER})
    -- Assign \(v\) to \(i\)-th entry.
    -- Always applicable: resize the array if \(i\) falls out of
    -- currently defined bounds; preserve existing items.
    -- New entries if any are initialized to default value.
ensure
    put: \text{item} (i) = v;
    higher_count: \text{count} \geq \text{old count}

put (v: \text{like item}; i: \text{INTEGER})
    -- Assign \(v\) to \(i\)-th entry.
require
    good_index: valid\_index (i)
ensure
    put: \text{item} (i) = v

feature -- Removal
remove (i: \text{INTEGER})
    -- Remove element at index \(i\) and shift elements between ranks \(i+1\) and \text{upper left}.
require
    good_index: valid\_index (i)
ensure
    same_lower: \text{lower} = \text{old lower};
    smaller_upper: \text{upper} = \text{old upper} - 1

remove\_first
    -- Remove first element and shift all elements leftwards.
require
    not\_is\_empty: not is\_empty
ensure
    same_lower: \text{lower} = \text{old lower};
    smaller_upper: \text{upper} = \text{old upper} - 1

remove\_last
    -- Remove last element.
require
    not\_is\_empty: not is\_empty
ensure
    same_lower: \text{lower} = \text{old lower};
    smaller_upper: \text{upper} = \text{old upper} - 1

wipe\_out
    -- Remove all elements.
ensure
    is\_empty: is\_empty
    same\_capacity: \text{capacity} = \text{old capacity}
    same\_lower: \text{lower} = \text{old lower}

feature -- Resizing
resize (minindex, maxindex: \text{INTEGER})
-- Rearrange array so that it can accommodate
-- indices down to minindex and up to maxindex.
-- Do not lose any previously entered item in the
-- intersection between [old lower .. old upper] and
-- [minindex .. maxindex].
-- New positions are initialized to their default value.

require
valid_indices: (minindex <= maxindex) or (maxindex = minindex - 1)

ensure
lower_set: lower = minindex
upper_set: upper = maxindex

feature -- Conversion
to_external: POINTER
-- Address of the storage area containing the actual sequence of elements,
-- to be passed to some external (non-Eiffel) routine.
-- Keep in mind that this storage area is subject to garbage collection.

feature -- Duplication
copy (other: like Current)
-- Reinitialize by copying all the items of other.
-- Shallow copy: if the elements are references, only the references
-- are copied, not the object they point to.
-- (Redefined from GENERAL.)

ensure
same_lower: lower = other.lower;
same_upper: upper = other.upper;
-- same_content: For every i in lower..upper,
-- item (i) = other.item (i)

feature -- Indexing
reindex (new_lower: INTEGER)
-- Change bounds according to new_lower, keeping same size and contents.

ensure
reindexed_lower: lower = new_lower;
same_contents: count = old_count;

feature -- Optimization
adjust_capacity (n: INTEGER)
-- Rearrange array so that it can accommodate
-- at least n elements.
-- Do not loose any previously entered element.

require
no_item_lost: n >= count

ensure
enough_capacity: capacity >= n

invariant
consistent_count: count = upper - lower + 1;
non_negative_count: count >= 0;
good_capacity: capacity >= count
5.13 Class STRING (current ELKS2000 status)

[indexing]

description: "Resizable sequences of characters, accessible through %
%integer indices in a contiguous range. If not empty, first element%
%is at index 1."

[class interface]

STRING

[creation]

make (n: INTEGER)
-- Allocate space for at least n characters.
require
    non_negative_size: n >= 0
ensure
    empty_string: count = 0
    correctly_allocated_size: capacity >= n

make_from_external (ptr: POINTER)
-- Set Current with a copy of the content of ptr.
-- Assume ptr is a null-terminated memory area containing
-- only characters.
-- The extra null character is not part of the Eiffel string
require
    ptr_exists: ptr /= default_pointer

make_from_string (s: STRING)
-- Initialize from the characters of s.
-- (Useful in proper descendants of class STRING,
-- to initialize a string-like object from a manifest string.)
require
    string_exists: s /= Void
ensure
    count_set: count = s.count

[feature -- Initialization]

make (n: INTEGER)
-- Allocate space for at least n characters.
require
    non_negative_size: n >= 0
ensure
    empty_string: count = 0
    correctly_allocated_size: capacity >= n

make_from_external (ptr: POINTER)
-- Set Current with a copy of the content of ptr.
-- Assume ptr is a null-terminated memory area containing
-- only characters.
-- The extra null character is not part of the Eiffel string
require
    ptr_exists: ptr /= default_pointer

make_from_string (s: STRING)
-- Initialize from the characters of s.
-- (Useful in proper descendants of class STRING,
-- to initialize a string-like object from a manifest string.)
require
    string_exists: s /= Void
ensure
    count_set: count = s.count

[feature -- Access]
first: CHARACTER
  -- First character of Current.
  require
  not_empty_string: not is_empty
  ensure
  good_result: Result = item (1)
  has (c: CHARACTER): BOOLEAN
  -- Does Current contain c?
  ensure
  definition: Result = (index_of(c) /= 0);
hash_code: INTEGER
  -- Hash code value
  -- (From HASHABLE.)
  ensure
  good_hash_value: Result >= 0
index_from (c: CHARACTER; start_index: INTEGER): INTEGER
  -- Index of first occurrence of c at or after start_index;
  -- 0 if none.
  require
  valid_start_index: valid_index (start_index)
  ensure
  non_negative_result: Result >= 0;
  valid_result: Result > 0 implies valid_index (Result)
  result_after_start_index: Result > 0 implies Result >= start_index;
  at_this_index: Result > 0 implies item (Result) = c;
  -- none_before: For every i in start_index..Result-1, item (i) /= c
  -- zero_iff_absent:
  --   (Result = 0) = For every i in start_index..count, item (i) /= c
index_of (c: CHARACTER): INTEGER
  -- Index of first occurrence of c;
  -- 0 if none.
  ensure
  empty_definition: empty implies Result = 0;
  non_empty_definition: not empty implies Result = index_from (c, 1);
infix "@", item (i: INTEGER): CHARACTER
  -- Character at index i
  require
  good_key: valid_index (i)
last: CHARACTER
  -- Last character of Current.
  require
  not_empty_string: not is_empty
  ensure
  good_result: Result = item (count)
reverse_index_from (c: CHARACTER; last_index: INTEGER): INTEGER
  -- Index of first occurrence of c at or before last_index;
  -- 0 if none.
  require
  valid_last_index: valid_index (last_index)
  ensure
  non_negative_result: Result >= 0;
  valid_result: Result > 0 implies valid_index(Result)
  result_before_last_index: Result > 0 implies Result <= last_index;
  at_this_index: Result > 0 implies item (Result) = c;
  -- none_before: Result > 0 implies For every i in Result+1..last_index, item (i) /= c
  -- zero_iff_absent:
  --   (Result = 0) = For every i in 1..last_index, item (i) /= c
reverse_index_of (c: CHARACTER): INTEGER
  -- Index of last occurrence of c;
  -- 0 if none.
  ensure
  empty_definition: empty implies Result = 0;
  non_empty_definition: empty implies Result = reverse_index_from (c, count);
reverse_string_index_from (other: STRING; last_index: INTEGER): INTEGER

-- Index of first occurrence of other at or before last_index;
-- 0 if none.

require
other_not_empty: not other.empty;
valid_last_index: valid_index (last_index)

ensure
non_negative_result: Result >= 0;
valid_result: Result > 0 implies valid_index (Result)
result_before_last_index: Result > 0 implies Result <= last_index;
at_this_index: Result > 0 implies other.is_equal (substring) (Result, Result - 1
-- none_before: Result > 0 implies
-- For every i in Result+1..last_index, not other.is_equal (substring (i, i
-- zero_iff_absent:
-- (Result = 0) = For every i in 1..last_index, not other.is_equal (substri

reverse_string_index_of (other: STRING): INTEGER
-- Index of last occurrence of other;
-- 0 if none.

require
other_not_empty: not other.empty

ensure
empty_definition: empty implies Result = 0;
non_empty_definition: not empty implies Result = reverse_string_index_from (oth

string_index_from (other: STRING; start_index: INTEGER): INTEGER
-- Index of first occurrence of other at or after start;
-- 0 if none.

require
other_not_empty: not other.empty;
valid_start_index: valid_index (start_index)

ensure
non_negative_result: Result >= 0;
valid_result: Result > 0 implies valid_index (Result)
result_after_start_index: Result > 0 implies Result >= start_index;
at_this_index: Result > 0 implies other.is_equal (substring) (Result, Result - 1
-- none_before: Result > 0 implies
-- For every i in start_index..Result-1, not other.is_equal (substring (i, .
-- zero_iff_absent:
-- (Result = 0) = For every i in start_index..count, not other.is_equal (sub

string_index_of (other: STRING): INTEGER
-- Index of first occurrence of other;
-- 0 if none.

require
other_not_empty: not other.empty

ensure
empty_definition: empty implies Result = 0;
non_empty_definition: not empty implies Result = reverse_string_index_from (oth

feature -- Measurement

count: INTEGER
-- Current number of characters making up the string

capacity: INTEGER
-- Number of characters that Current can currently contain in the internal stor;
-- Automatically updated when resizing is needed. Useful for fine tuning.

occurrences (c: CHARACTER): INTEGER
-- Number of times c appears in the string

ensure
non_negative_occurrences: Result >= 0

feature -- Comparison

is_equal (other: like Current): BOOLEAN
-- Is string made of same character sequence as other?
-- (Redefined from GENERAL.)

require
other_exists: other /= Void

infix "<" (other: like Current): BOOLEAN
-- Is string lexicographically lower than other?
require other_exists: other /= Void
ensure asymmetric: Result implies not (other < Current)

infix "<=" (other: like Current): BOOLEAN
-- Is current object less than or equal to other?
-- (From COMPARABLE.)
require other_exists: other /= Void
ensure
definition: Result = (Current < other) or is_equal (other);

infix ">=" (other: like Current): BOOLEAN
-- Is current object greater than or equal to other?
-- (From COMPARABLE.)
require other_exists: other /= Void
ensure
definition: Result = (other <= Current)

max (other: like Current): like Current
-- The greater of current object and other
-- (From COMPARABLE.)
require other_exists: other /= Void
ensure
current_if_not_smaller: (Current >= other) implies (Result = Current)
other_if_smaller: (Current < other) implies (Result = other)

min (other: like Current): like Current
-- The smaller of current object and other
-- (From COMPARABLE.)
require other_exists: other /= Void
ensure
current_if_not_greater: (Current <= other) implies (Result = Current)
other_if_greater: (Current > other) implies (Result = other)

same_as (other: STRING): BOOLEAN
-- Is string made of same character sequence as other?
-- Case insensitive comparison.
require other_exists: other /= Void

three_way_comparison (other: like Current): INTEGER
-- If current object equal to other, 0; if smaller, -1; if greater, 1.
-- (From COMPARABLE.)
require other_exists: other /= Void
ensure
equal_zero: (Result = 0) = is_equal (other);
smaller: (Result = -1) = Current < other;
greater_positive: (Result = 1) = Current > other

feature -- Status report
is_empty: BOOLEAN
-- Is string empty?
ensure
definition: Result = (count = 0)
valid_index (index: INTEGER): BOOLEAN
   -- Is i within the bounds of the string?
   ensure
definition: Result = (1 <= index and index <= count)

is_boolean: BOOLEAN
   -- Is Current representing a boolean ("true" or "false" with no
   -- case consideration)?

is_double: BOOLEAN
   -- Can Current be read as a DOUBLE?

is_integer: BOOLEAN
   -- Can Current be read as an INTEGER?

is_real: BOOLEAN
   -- Can Current be read as a REAL?

feature -- Element change

add, insert (c: CHARACTER; i: INTEGER)
   -- Insert c at index i, shifting characters between ranks i and count rightward:
   require
   valid_insertion_index: 1 <= i and i <= count + 1
   ensure
   inserted: item (i) = c
   one_more_character: count = old count + 1

add_first, precede (c: CHARACTER)
   -- Prepend c at beginning.
   ensure
   inserted: first = c
   one_more_character: count = old count + 1

add_last, append_character, extend (c: CHARACTER)
   -- Append c at end.
   ensure
   inserted: last = c
   one_more_character: count = old count + 1

append, append_string (s: STRING)
   -- Append a copy of s at end.
   require
   other_exists: s /= Void
   ensure
   new_count: count = old count + old s.count
   -- appended: For every i in 1..old s.count,
   -- item (old count + i) = s.item (i)

append_boolean (b: BOOLEAN)
   -- Append the string representation of b at end.
   ensure
   boolean_inserted: reverse_index_of (b.out) = count - b.out.count
   new_count: count = old count + b.out.count + 1

append_double (d: DOUBLE)
   -- Append the string representation of d at end.
   ensure
double_inserted: reverse_index_of (d.out) = count - d.out.count
   new_count: count = old count + d.out.count + 1

append_integer (i: INTEGER)
   -- Append the string representation of i at end.
   ensure
integer_inserted: reverse_index_of (i.out) = count - i.out.count
   new_count: count = old count + i.out.count + 1

append_real (r: REAL)
   -- Append the string representation of r at end.
   ensure
real_inserted: reverse_index_of (r.out) = count - r.out.count
   new_count: count = old count + r.out.count + 1

fill (c: CHARACTER)
-- Replace every character with c.
ensure  
same_count: old count = count  
filled: occurrences(c) = count

head (n: INTEGER)
-- Remove all characters except for the first n;
-- do nothing if n >= count.
require  
non_negative_argument: n >= 0  
ensure  
new_count: count = n.min (old count)  
-- first_kept: For every i in 1..n, item (i) = old item (i)

insert_string (s: like Current; i: INTEGER)
-- Insert s at index i, shifting characters between ranks i and count rightward:
require  
string_exists: s /= Void;  
valid_insertion_index: 1 <= i and i <= count + 1  
ensure  
new_count: count = old count + old s.count  
inserted: s.is_equal (substring (i, i - 1 + old s.count))

left_adjust
-- Remove leading white space.
ensure  
shorter: count <= old count  
first_not_white_space: not is_empty implies ("%T%R%N ").index_of (first) = 0

put (c: CHARACTER; i: INTEGER)
-- Replace character at index i by c.
require  
good_key: valid_index (i)  
ensure  
insertion_done: item (i) = c

right_adjust
-- Remove trailing white space.
ensure  
shorter: count <= old count  
last_not_white_space: not is_empty implies ("%T%R%N ").index_of (last) = 0

subcopy (other: like Current; start_pos, end_pos, from_index: INTEGER) is
-- Copy characters of other within bounds start_pos and
-- end_pos to current string starting at index from_index.
require  
other_not_void: other /= Void;  
valid_start_pos: other.valid_index (start_pos)  
valid_end_pos: other.valid_index (end_pos)  
valid_bounds: start_pos <= end_pos  
valid_from_index: valid_index (from_index)  
enough_space: valid_index (from_index + end_pos - start_pos)
ensure  
same_count: old count = count  
copied: substring (from_index, from_index + end_pos - start_pos).is_equal  
(other.substring (start_pos, end_pos))

tail (n: INTEGER)
-- Remove all characters except for the last n;
-- do nothing if n >= count.
require  
non_negative_argument: n >= 0  
ensure  
new_count: count = n.min (old count)

feature -- Removal
remove (i: INTEGER)
-- Remove i-th character, shifting characters between ranks i + 1 and count le.
require  
valid_removal_index: valid_index (i)  
ensure  
new_count: count = old count - 1
wipe_out
  -- Remove all characters.
ensure
  empty_string: is_empty
  same_capacity: capacity = old capacity
  same_lower: lower = old lower

feature -- Conversion

to_boolean: BOOLEAN
  -- Boolean value;
  -- "true" yields true, "false" yields false
  -- (case-insensitive)
require
  is_boolean: is_boolean

to_double: DOUBLE
  -- Double value; for example, when applied to "123.0",
  -- will yield 123.0 (double)
require
  is_double: is_integer or is_real or is_double

to_external: POINTER
  -- Address of the storage area containing the actual sequence of characters,
  -- to be passed to some external (non-Eiffel) routine.
  -- Keep in mind that this storage area is subject to garbage collection.

to_integer: INTEGER
  -- Integer value;
  -- for example, when applied to "123", will yield 123
require
  is_integer: is_integer

to_lower
  -- Convert to lower case.

to_real: REAL
  -- Real value;
  -- for example, when applied to "123.0", will yield 123.0
require
  is_real: is_integer or is_real

to_upper
  -- Convert to upper case.

feature -- Duplication

copy (other: like Current)
  -- Reinitialize by copying the characters of other.
  -- (From GENERAL.)
ensure
  new_result_count: count = other.count
  -- same_characters: For every i in 1..count,
  -- item (i) = other.item (i)

infix "+" (other: STRING): like Current
  -- Create a new object which is the concatenation of Current and other.
require
  other_exists: other /= Void
ensure
  result_exists: Result.count = count + other.count

substring (start_index, end_index: INTEGER): like Current
  -- Create a substring containing all characters from start_index
  -- to end_pos included.
require
  valid_start_index: valid_index (start_index)
  valid_end_index: valid_index (end_index)
  meaningful_interval: start_index <= end_index
ensure
  new_result_count: Result.count = end_index - start_index + 1
  -- original_characters: For every i in 1..end_index - start_index + 1,
  -- Result.item (i) = item (start_index + i -1)
**feature** -- Output

```plaintext
out: STRING
    -- Printable representation
    -- (From GENERAL.)

ensure
    result_not_void: Result /= Void
    duplicated_result: Result /= Current and Result.is_equal (Current)
```

**feature** -- Optimization

```plaintext
adjust_capacity (n: INTEGER)
    -- Rearrange string so that it can accommodate
    -- at least n characters.
    -- Do not lose any previously entered character.

require
    no_item_lost: n >= count

ensure
    enough_capacity: capacity >= n
```

**invariant**

```plaintext
non_negative_count: count >= 0
capacity_big_enough: capacity >= count
```

**end**
ELKS 2000 initial proposal

Content

- Preamble.
- In Progress for the new standard
- Off standard for the time being
- People Behind

Preamble

This work is a proposal for the new standard ELKS for two classes: ARRAY and STRING.

It is not intended to be the whole new standard, but only part of it. Indeed, because ELKS hasn’t evolved at all since 1995, we decided to invest a reasonable but limited amount of time and work to see whether it was possible to make things go ahead a bit.

If, after discussions and possibly modifications, this proposal for ARRAY and STRING is officially accepted in a reasonable amount of time and published by NICE as part of the new standard (which would be the first evolution since 1995...), we will continue working on other classes and topics for the new standard. Otherwise, we will, as most people so far who have been trying to improve ELKS, consider we have wasted our time and efforts and give up.

This work is mostly considered as a (major) cleanup of ELKS’95 for ARRAY and STRING, not as an extension to it. Once good basis are agreed on, extensions may be discussed more easily.

(This preamble was written by Dominique Colnet and Olivier Zendra, from the SmallEiffel team. As far as we know, these views are shared by Emmanuel Stapf, from ISE. However, since he could not take part in writing this, neither him or ISE are committed by this.)

In Progress for the new standard

STRING (Note: this list may be incomplete. initial_string.html is the actual reference. )

1. Introduced capacity.
2. make is not frozen anymore.
3. Removed remake and resize.
4. Renamed empty into is_empty.
5. Reviewed most of the assertions to use valid_index instead of the explicit use of the comparison of index to 1 and count.
6. Renamed from_c into make_from_external
7. Added a new creation procedure make_from_external and to_external
8. Introduced a new set of routines to do some string search based on character/string search from with/without a start/last index which can do the search from the beginning or from the end:

- index_from
- index_of
- reverse_index_from
- reverse_string_index_of
- reverse_index_of
- reverse_string_index_from
- string_index_from
- string_index_of
9. Changed the post-conditions of left_adjust and right_adjust which were completely wrong.
10. Removed put_substring and replace it by subcopy a multipurpose string routine manipulation with a clear comment.
11. Changed insert and insert_character into insert_string and insert. Clarified the purpose of those two
features. Added \textit{add} as a synonym of \textit{insert}.
12. Introduced \textit{adjust\_capacity} which replaces \textit{resize} with a more explicit meaning.
13. Introduced \textit{first} and \textit{last} to get the first and the last character of a \texttt{STRING}.
14. New \texttt{STRING} class invariant: \textit{capacity} \texttt{>=} \textit{count}.
15. Added post-conditions to the \texttt{append\_\_} features.
16. Added \textit{extend} and \textit{add\_last} as a synonym of \texttt{append\_character} and \texttt{append} as a synonym of \texttt{append\_\_}.
17. Added \textit{is\_boolean}, \textit{is\_integer}, \textit{is\_real} and \textit{is\_double} features.
18. Added \textit{same\_as} which does a case insensitive comparison between two strings.
19. Added \textit{add\_first} and \textit{precede}.
20. Added \textit{infix +} to append two strings.

\textbf{ARRAY} (Note: this list may be incomplete. \texttt{initial\_array.html} is the actual reference.)

1. Removed \textit{entry} and \textit{enter}.
2. \texttt{item}, \texttt{put} and \texttt{@} are not frozen anymore.
3. Changed the assertions of \texttt{make}.
4. Added a precondition to \texttt{make\_from\_array}.
5. Added \texttt{capacity} and the class invariant \texttt{capacity} \texttt{>=} \texttt{count}.
6. Changed the definition of \texttt{resize}.
7. Use of \texttt{equal} as comparison operator for the new search algorithms (\texttt{has}, \texttt{index\_of}, \texttt{reverse\_index\_of})
8. Removed ambiguity on \texttt{is\_equal} and \texttt{copy}
9. Renamed \texttt{to\_c} into \texttt{to\_external}.
10. Added \texttt{is\_empty}, \texttt{occurrences}, \texttt{first} and \texttt{last}.
11. Added \texttt{add}, \texttt{add\_first} and \texttt{add\_last}.
12. Added \texttt{remove}, \texttt{remove\_first} and \texttt{remove\_last}.

\section*{Off standard for the time being}

\textbf{MANIFEST\_STRING} or \textbf{CONSTANT\_STRING}

Very important language/libraries issues were also discussed about the semantics of \texttt{STRING}. In a nutshell, there are two problems:

1. The current semantics of an instruction such as
   \begin{verbatim}
   foo := "FOO";
   \end{verbatim}
   is not very clear and various compilers have different implementation for this. Some create a new object, other consider this instruction as a call to a once function (like for the declaration \tt{foo: STRING is "FOO";}). This at least must be clarified.
2. \texttt{STRING}s are mutable. Adding immutable (constant) strings would be a significant improvement, both in terms of performance (potential optimizations) and expressiveness (and safety).

After discussing this, it seems that the correct implementation in the long term would be the following:

1. Mutable \texttt{STRING}s and immutable \textbf{CONSTANT\_STRING} (or another name).
2. "FOO" is the notation for a \textbf{CONSTANT\_STRING}.
3. It must be possible to compare two \textbf{CONSTANT\_STRING}s with '=' with the same semantics as \texttt{is\_equal}.

\textbf{NATIVE\_ARRAY}

Aside the high-level, flexible, \texttt{ARRAY} class, it seems important to provide a standard low-level, C-like, array for optimal performances, like the \texttt{NATIVE\_ARRAY[E]} class provided with SmallEiffel.

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Last Update: 20 August 1999.
5.12 Class ARRAY (initial ELKS2000 proposal)

[Please don’t report broken URLs because this page is a draft. ]

indexing

description: "Resizable sequences of values, all of the same type or of a §
%conforming one, accessible through integer indices in a §
%contiguous interval"

class interface

ARRAY [G]

creation

make (minindex, maxindex: INTEGER)
  -- Allocate array; set index interval to
  -- minindex .. maxindex; set all values to default.
  -- (Make array empty if minindex > maxindex.)
require
  valid_indices: (minindex <= maxindex) or (maxindex = minindex - 1)
ensure
  lower_set: lower = minindex
  upper_set: upper = maxindex
  -- array_set: for i in minindex..maxindex, item(i) = default item
make_from_array (a: ARRAY [G])
  -- Initialize from the items of a.
  -- (Useful in proper descendants of class ARRAY,
  -- to initialize an array-like object from a manifest array.)
require
  valid_array: a /= Void
feature -- Initialization

make (minindex, maxindex: INTEGER)
  -- Set index interval to minindex .. maxindex;
  -- reallocate if necessary; set all values to default.
  -- (Make array empty if minindex > maxindex.)
require
  valid_indices: (minindex <= maxindex) or (maxindex = minindex - 1)
ensure
  lower_set: lower = minindex
  upper_set: upper = maxindex
  -- array_set: for i in minindex..maxindex, item(i) = default item
make_from_array (a: ARRAY [G])
  -- Initialize from the items of a; reallocate if
  -- necessary. (Useful in proper descendants of
  -- class ARRAY, to initialize an array-like object
  -- from a manifest array.)
require
  valid_array: a /= Void
feature -- Access

first: like item
  -- First element
require
  not_empty: not is_empty
ensure
definition: Result = item (lower)

has (v: like item): BOOLEAN
  -- Does Current contain v?
  -- Use equal as comparison operator.
ensure
definition: Result = valid_index(index_of(c));
index_of (v: like item): INTEGER  
-- Index of first occurrence of v  
-- Use equal as comparison operator.  
-- Upper + 1 if not found  
ensure  
   not_found: (Result = upper + 1) = not has(v);  
found: has(v) implies equal(v, item(Result));

infix "[@", item (i: INTEGER): G  
-- Entry at index i  
require  
   good_key: valid_index (i)

last: like item  
-- Last element  
require  
   not_empty: not is_empty  
ensure  
   definition: Result = item (upper)

reverse_index_of (v: like item): INTEGER  
-- Index of last occurrence of v?  
-- Use equal as comparison operator.  
-- Lower - 1 if not found  
ensure  
   not_found: (Result = upper + 1) = not has(v);  
found: has(v) implies equal(v, item(Result));

feature -- Measurement  

capacity: INTEGER  
-- Current number of elements that Current can contain.

count: INTEGER  
-- Number of valid indices  
ensure  
   definition: Result = upper - lower + 1;

lower: INTEGER  
-- Minimum valid index

occurrences (v: like item): INTEGER  
-- Number of times v appears in Current.  
-- Use equal as comparison operator.  
ensure  
   non_negative_occurrences: Result >= 0

upper: INTEGER  
-- Maximum valid index

feature -- Comparison  

is_equal (other: like Current): BOOLEAN  
-- Do both arrays have same lower, upper and  
-- items (compared with is_equal)?  
-- (Redefined from GENERAL.)

feature -- Status report  

is_empty: BOOLEAN  
-- Is array empty?  
ensure  
   definition: Result = (count = 0)

valid_index (i: INTEGER): BOOLEAN  
-- Is i within the bounds of the array?  
ensure  
   definition: lower <= i and i <= upper

feature -- Element change  

add (v: like item; i: INTEGER)  
-- Insert v at index I, shifting elements between ranks i and upper rightwards.  
require
valid_insertion_index: lower <= i and i <= upper + 1

ensure
inserted: item (i) = v;
same_lower: lower = old lower;
higher_upper: upper = old upper + 1

add_first (v: like item)

-- Insert v at index lower, shifting all elements rightwards.

ensure
inserted: first = v;
same_lower: lower = old lower;
higher_upper: upper = old upper + 1

add_last (v: like item)

-- Append v at end.

ensure
inserted: last = v;
same_lower: lower = old lower;
higher_upper: upper = old upper + 1

force (v: like item; i: INTEGER)

-- Assign v to i-th entry.
-- Always applicable: resize the array if i falls out of
-- currently defined bounds; preserve existing items.
-- New entries if any are initialized to default value.

ensure
put: item (i) = v;
higher_count: count >= old count

put (v: like item; i: INTEGER)

-- Assign v to i-th entry.

require
good_index: valid_index (i)

ensure
put: item (i) = v

feature -- Removal

remove (i: INTEGER)

-- Remove element at index i and shift elements between ranks i+1 and upper left!

require
good_index: valid_index (i)

ensure
same_lower: lower = old lower;
smaller_upper: upper = old upper - 1

remove_first

-- Remove first element and shift all elements leftwards.

require
not_is_empty: not is_empty

ensure
same_lower: lower = old lower;
smaller_upper: upper = old upper - 1

remove_last

-- Remove last element.

require
not_is_empty: not is_empty

ensure
same_lower: lower = old lower;
smaller_upper: upper = old upper - 1

wipe_out

-- Remove all elements.

ensure
is_empty: is_empty
same_capacity: capacity = old capacity

feature -- Resizing

resize (minindex, maxindex: INTEGER)
-- Rearrange array so that it can accommodate
-- indices down to minindex and up to maxindex.
-- Do not lose any previously entered item in the
-- intersection between [old lower .. old upper] and
-- [minindex .. maxindex].
-- New positions are initialized to their default value.

require
  valid_indices: (minindex <= maxindex) or (maxindex = minindex - 1)

ensure
  lower_set: lower = minindex
  upper_set: upper = maxindex

feature -- Conversion
  to_external: POINTER
  -- Address of the storage area containing the actual sequence of elements,
  -- to be passed to some external (non-Eiffel) routine.
  -- Keep in mind that this storage area is subject to garbage collection.

feature -- Duplication
  copy (other: like Current)
  -- Reinitialize by copying all the items of other.
  -- Shallow copy: if the elements are references, only the references
  -- are copied, not the object they point to.
  -- (Redefined from GENERAL.)

  ensure
    same_lower: lower = other.lower;
    same_upper: upper = other.upper;
    -- same_content: For every i in lower..upper,
    --     item (i) = other.item (i)

invariant

  consistent_count: count = upper - lower + 1;
  non_negative_count: count >= 0;
  good_capacity: capacity >= count

end
5.13 Class STRING (initial ELKS2000 proposal)

indexing

description: "Resizable sequences of characters, accessible through % %integer indices in a contiguous range. If not empty, first element% %is at index 1."

class interface

STRING

creation

make (n: INTEGER)
  -- Allocate space for at least n characters.
  require
  non_negative_size: n >= 0
  ensure
  empty_string: count = 0
  correctly_allocated_size: capacity >= n

make_from_external (ptr: POINTER)
  -- Set Current with a copy of the content of ptr.
  -- Assume ptr is a null-terminated memory area containing
  -- only characters.
  -- The extra null character is not part of the Eiffel string
  require
  ptr_exists: ptr /= default_pointer

make_from_string (s: STRING)
  -- Initialize from the characters of s.
  -- (Useful in proper descendants of class STRING,
  -- to initialize a string-like object from a manifest string.)
  require
  string_exists: s /= Void
  ensure
  count_set: count = s.count

feature -- Initialization

make (n: INTEGER)
  -- Allocate space for at least n characters.
  require
  non_negative_size: n >= 0
  ensure
  empty_string: count = 0
  correctly_allocated_size: capacity >= n

make_from_external (ptr: POINTER)
  -- Set Current with a copy of the content of ptr.
  -- Assume ptr is a null-terminated memory area containing
  -- only characters.
  -- The extra null character is not part of the Eiffel string
  require
  ptr_exists: ptr /= default_pointer

make_from_string (s: STRING)
  -- Initialize from the characters of s.
  -- (Useful in proper descendants of class STRING,
  -- to initialize a string-like object from a manifest string.)
  require
  string_exists: s /= Void
  ensure
  count_set: count = s.count

feature -- Access
first: CHARACTER
  -- First character of Current.
require
  not_empty_string: not is_empty
ensure
  good_result: Result = item (i)
has (c: CHARACTER): BOOLEAN
  -- Does Current contain c ?
ensure
  definition: Result = (index_of(c) /= 0);
hash_code: INTEGER
  -- Hash code value
  -- (From HASHABLE.)
ensure
  good_hash_value: Result >= 0
index_from (c: CHARACTER; start_index: INTEGER): INTEGER
  -- Index of first occurrence of c at or after start_index;
  -- 0 if none.
require
  valid_start_index: valid_index (start_index)
ensure
  non_negative_result: Result >= 0;
  valid_result: Result > 0 implies valid_index (Result)
  at_this_index: Result > 0 implies Result >= start_index;
  none_before: For every i in start_index..Result, item (i) /= c
  zero_iff_absent:
    -- (Result = 0) = For every i in start_index..count, item (i) /= c
index_of (c: CHARACTER): INTEGER
  -- Index of first occurrence of c;
  -- 0 if none.
ensure
  empty_definition: empty implies Result = 0;
  non_empty_definition: not empty implies Result = index_from (c, 1);
infix "@", item (i: INTEGER): CHARACTER
  -- Character at index i
require
  good_key: valid_index (i)
last: CHARACTER
  -- Last character of Current.
require
  not_empty_string: not is_empty
ensure
  good_result: Result = item (count)
reverse_index_from (c: CHARACTER; last_index: INTEGER): INTEGER
  -- Index of first occurrence of c at or before last_index;
  -- 0 if none.
require
  valid_last_index: valid_index (last_index)
ensure
  non_negative_result: Result >= 0;
  valid_result: Result > 0 implies valid_index(Result)
  result_before_last_index: Result <= last_index;
  at_this_index: Result > 0 implies item (Result) = c;
  none_before: For every i in Result..last_index, item (i) /= c
  zero_iff_absent:
    -- (Result = 0) = For every i in 1..last_index, item (i) /= c
reverse_index_of (c: CHARACTER): INTEGER
  -- Index of last occurrence of c;
  -- 0 if none.
ensure
  empty_definition: empty implies Result = 0;
  non_empty_definition: empty implies Result = reverse_index_from (c, count);
reverse_string_index_from (other: STRING; last_index: INTEGER): INTEGER
require
other_not_empty: not other.empty;
valid_last_index: valid_index (last_index)
ensure
non_negative_result: Result >= 0;
valid_result: Result > 0 implies valid_index (Result)
result_before_last_index: Result > 0 implies Result <= last_index;
at_this_index: Result > 0 implies other.is_equal (substring (Result, Result - 1
-- none_before:
-- For every i in Result..last_index, not other.is_equal (substring (i, i -
-- zero_iff_absent:
-- (Result = 0) = For every i in i..last_index, not other.is_equal (substri

reverse_string_index_of (other: STRING): INTEGER
-- Index of last occurrence of other;
-- 0 if none.
require
other_not_empty: not other.empty
ensure
empty_definition: empty implies Result = 0;
non_empty_definition: not empty implies Result = reverse_string_index_from (oth

string_index_from (other: STRING; start_index: INTEGER): INTEGER
-- Index of first occurrence of other at or after start;
-- 0 if none.
require
other_not_empty: not other.empty;
valid_start_index: valid_index (start_index)
ensure
non_negative_result: Result >= 0;
valid_result: Result > 0 implies valid_index (Result)
result_after_start_index: Result > 0 implies Result >= start_index;
at_this_index: Result > 0 implies other.is_equal (substring (Result, Result - 1
-- none_before:
-- For every i in start_index..Result, not other.is_equal (substring (i, i -
-- zero_iff_absent:
-- (Result = 0) = For every i in start_index..count, not other.is_equal (su

string_index_of (other: STRING): INTEGER
-- Number of times c appears in the string
require
other_not_empty: not other.empty
ensure
non_negative_occurrences: Result >= 0

feature -- Measurement

count: INTEGER
-- Current number of characters making up the string

capacity: INTEGER
-- Current number of characters that the string
-- can contain.

occurrences (c: CHARACTER): INTEGER
-- Number of times c appears in the string
ensure
non_negative_occurrences: Result >= 0

feature -- Comparison

is_equal (other: like Current): BOOLEAN
-- Is string made of same character sequence as other?
-- (Redefined from GENERAL.)
require
other_exists: other /= Void

infix "<" (other: like Current): BOOLEAN
-- Is string lexicographically lower than other?
require
other_exists: other /= Void
ensure
asymmetric: Result implies not (other < Current)
infix "<=" (other: like Current): BOOLEAN
-- Is current object less than or equal to other?
-- (From COMPARABLE.)
require
other_exists: other /= Void
ensure
definition: Result = (Current < other) or is_equal (other);
infix ">=" (other: like Current): BOOLEAN
-- Is current object greater than or equal to other?
-- (From COMPARABLE.)
require
other_exists: other /= Void
ensure
definition: Result = (other <= Current)
max (other: like Current): like Current
-- The greater of current object and other
-- (From COMPARABLE.)
require
other_exists: other /= Void
ensure
current_if_not_smaller: (Current >= other) implies (Result = Current)
other_if_smaller: (Current < other) implies (Result = other)
min (other: like Current): like Current
-- The smaller of current object and other
-- (From COMPARABLE.)
require
other_exists: other /= Void
ensure
current_if_not_greater: (Current <= other) implies (Result = Current)
other_if_greater: (Current > other) implies (Result = other)
same_as (other: STRING): BOOLEAN
-- Is string made of same character sequence as other?
-- Case insensitive comparison.
require
other_exists: other /= Void
ensure
equal_zero: (Result = 0) = is_equal (other);
smaller: (Result = -1) = Current < other;
greater_positive: (Result = 1) = Current > other
feature -- Status report
is_empty: BOOLEAN
-- Is string empty?
ensure
definition: Result = (count = 0)
valid_index (index: INTEGER): BOOLEAN
-- Is i within the bounds of the string?
ensure
definition: Result = (1 <= index and index <= count)

is_boolean: BOOLEAN
-- Is Current representing a boolean ("true" or "false" with no
-- case consideration)?

is_double: BOOLEAN
-- Can Current be read as a DOUBLE?

is_integer: BOOLEAN
-- Can Current be read as an INTEGER?

is_real: BOOLEAN
-- Can Current be read as a REAL?

feature -- Element change

add, insert (c: CHARACTER; i: INTEGER)
-- Insert c at index i, shifting characters between ranks i and count rightward:
require
valid_insertion_index: 1 <= i and i <= count + 1
ensure
inserted: item (i) = c
one_more_character: count = old count + 1

add_first, precede (c: CHARACTER)
-- Prepend c at beginning.
ensure
inserted: first = c
one_more_character: count = old count + 1

add_last, append_character, extend (c: CHARACTER)
-- Append c at end.
ensure
inserted: last = c
one_more_character: count = old count + 1

append, append_string (s: STRING)
-- Append a copy of s at end.
require
other_exists: s /= Void
ensure
new_count: count = old count + s.count
-- appended: For every 1 in 1.. s.count,
-- item (old count + i) = s.item (i)

append_boolean (b: BOOLEAN)
-- Append the string representation of b at end.
ensure
boolean_inserted: reverse_index_of (b.out) = count - b.out.count
new_count: count = old count + b.out.count + 1

append_double (d: DOUBLE)
-- Append the string representation of d at end.
ensure
double_inserted: reverse_index_of (d.out) = count - d.out.count
new_count: count = old count + d.out.count + 1

append_integer (i: INTEGER)
-- Append the string representation of i at end.
ensure
integer_inserted: reverse_index_of (i.out) = count - i.out.count
new_count: count = old count + i.out.count + 1

append_real (r: REAL)
-- Append the string representation of r at end.
ensure
real_inserted: reverse_index_of (r.out) = count - r.out.count
new_count: count = old count + r.out.count + 1

fill (c: CHARACTER)
ensures same_count: old count = count
filled: occurrences(c) = count

head (n: INTEGER)
-- Remove all characters except for the first n;
-- do nothing if n >= count.
requires non_negative_argument: n >= 0
ensures new_count: count = n.min(old count)
first_kept: For every i in 1..n, item (i) = old item (i)

insert_string (s: like Current; i: INTEGER)
-- Insert s at index i, shifting characters between ranks i and count rightward:
requires string_exists: s /= Void;
valid_insertion_index: 1 <= i and i <= count + 1
ensures new_count: count = old count + s.count
inserted: s.is_equal(substring(i, i - 1 + s.count))

left_adjust
-- Remove leading white space.
ensures shorter: count <= old count
first_not_white_space: not is_empty implies (%T%R%N ).index_of (first) = 0

put (c: CHARACTER; i: INTEGER)
-- Replace character at index i by c.
requires good_key: valid_index (i)
ensures insertion_done: item (i) = c

right_adjust
-- Remove trailing white space.
ensures shorter: count <= old count
last_not_white_space: not is_empty implies (%T%R%N ).index_of (last) = 0

subcopy (other: like Current; start_pos, end_pos, from_index: INTEGER) is
-- Copy characters of other within bounds start_pos and
-- end_pos to current string starting at index from_index.
requires other_not_void: other /= Void;
valid_start_pos: other.valid_index (start_pos)
valid_end_pos: other.valid_index (end_pos)
valid_bounds: start_pos <= end_pos
valid_from_index: valid_index (from_index)
enough_space: valid_index (from_index + end_pos - start_pos)
enough_space: valid_index (from_index + end_pos - start_pos)
ensures same_count: old count = count
copied: substring (from_index, from_index + end_pos - start_pos).is_equal
(other.substring (start_pos, end_pos))

tail (n: INTEGER)
-- Remove all characters except for the last n;
-- do nothing if n >= count.
requires non_negative_argument: n >= 0
ensures new_count: count = n.min(old count)

feature -- Removal
remove (i: INTEGER)
-- Remove i-th character, shifting characters between ranks i + 1 and count le.
requires valid_removal_index: valid_index (i)
ensures new_count: count = old count - 1
wipe_out
-- Remove all characters.

ensure
empty_string: is_empty
same_capacity: capacity = old_capacity

feature -- Resizing
adjust_capacity (n: INTEGER)
-- Rearrange string so that it can accommodate
-- at least n characters.
-- Do not lose any previously entered character.

require
no_item_lost: n >= count

ensure
enough_capacity: capacity >= n

feature -- Conversion
to_boolean: BOOLEAN
-- Boolean value; "true" yields true, "false" yields false
-- (case-insensitive)

require
is_boolean: is_boolean

to_double: DOUBLE
-- Double value; for example, when applied to "123.0",
-- will yield 123.0 (double)

require
is_double: is_integer or is_real or is_double

to_external: POINTER
-- Address of the storage area containing the actual sequence of characters,
-- to be passed to some external (non-Eiffel) routine.
-- Keep in mind that this storage area is subject to garbage collection.

to_integer: INTEGER
-- Integer value;
-- for example, when applied to "123", will yield 123

require
is_integer: is_integer

to_lower
-- Convert to lower case.

to_real: REAL
-- Real value;
-- for example, when applied to "123.0", will yield 123.0

require
is_real: is_integer or is_real

to_upper
-- Convert to upper case.

feature -- Duplication
copy (other: like Current)
-- Reinitialize by copying the characters of other.
-- (From GENERAL.)

ensure
new_result_count: count = other.count
-- same_characters: For every i in 1..count,
-- item (i) = other.item (i)

infix "+" (other: STRING): like Current
-- Create a new object which is the concatenation of Current and other.

require
other_exists: other /= Void

ensure
result_count: Result.count = count + other.count

substring (start_index, end_index: INTEGER): like Current
require
valid_start_index: valid_index (start_index)
valid_end_index: valid_index (end_index)
meaningful_interval: start_index <= end_index

ensure
new_result_count: Result.count = end_index - start_index + 1
-- original_characters: For every i in 1..end_index - start_index + 1,
-- Result.item (i) = item (start_index + i - 1)

feature -- Output

out: STRING
-- Printable representation
-- (From GENERAL)

ensure
result_not_void: Result /= Void
duplicated_result: Result /= Current and Result.is_equal (Current)

invariant

non_negative_count: count >= 0
capacity_big_enough: capacity >= count

end
ELKS 2000 proposal changelog

Preamble

This page lists the changes made to the initial ELKS2000 proposal (initial_string.html and initial_array.html) to obtain the current ELKS2000 proposal (current_string.html and current_array.html).

These changes result from the discussions in the NICE mailing list dedicated to library issues, http://www.egroups.com/group/eiffel-nice-library.

Of course, only those changes that have been agreed upon are put in here.

Changes (latest first)

15 September 1999:
- Fixed postcondition of append, append_string and insert_string in STRING.

01 September 1999:
- Moved adjust_capacity from Resizing feature clause to Optimization feature clause in ARRAY and STRING.
- Added reindex feature in class ARRAY.

30 August 1999:
- Updated comments for capacity in ARRAY and STRING.
- Made postcondition same_lower explicit in wipe_out of ARRAY and STRING.

20 August 1999:
- Added these ELKS2000 pages.
- Added adjust_capacity in ARRAY (was mistakenly forgotten in the initial proposal), like in STRING.
- Fixed mistakes in postcondition --none_before: for routines index_from, string_index_from, reverse_index_from, and reverse_string_index_from of class STRING.

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