```
#|

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|#
```

EVENT: Start with the library "mc20-2" using the compiled version.

```
;         Proof of the Corectness of a Majority Voting Program
;
#|
The following C function MJRTY determines if there is a candidate who
has received a majority of votes cast in an election.

/* a majority voting algorithm invented by Boyer and Moore */
#define YES 1
#define NO  0

struct winner {
  int x;
  int y;
};

struct winner mjrty (int a[], int n)
```

```
{
  int cand, i, k;
  struct winner temp;

  k = 0;
  for (i = 0; i < n; i++)
    if (k == 0) {
      cand = a[i];
      k = 1;
    }
  else {
    if (cand == a[i])
      k++;
    else
      k--;
  };
  temp.x = cand;
  if (k == 0) {
    temp.y = NO;
    return temp;
  };
  if (k > n/2) {
    temp.y = YES;
    return temp;
  };
  k = 0;
  for (i = 0; i < n; i++)
    if (a[i] == cand)
      k++;
  if (k > n/2)
    temp.y = YES;
  else temp.y = NO;
  return temp;
}
```

Here is the MC68020 assembly code of the above C program. The code is generated by "gcc -O".

```
0x2310 <mjrty>:         linkw a6,#0
0x2314 <mjrty+4>:       moveml d2-d5,sp@-
0x2318 <mjrty+8>:       moveal a6@(8),a0
0x231c <mjrty+12>:      movel a6@(12),d2
0x2320 <mjrty+16>:      clrl d1
0x2322 <mjrty+18>:      clrl d0
```

```
0x2324 <mjrty+20>:      cmpl d0,d2
0x2326 <mjrty+22>:      ble 0x2346 <mjrty+54>
0x2328 <mjrty+24>:      tstl d1
0x232a <mjrty+26>:      bne 0x2334 <mjrty+36>
0x232c <mjrty+28>:      movel 0(a0)[d0.l*4],d3
0x2330 <mjrty+32>:      movel #1,d1
0x2332 <mjrty+34>:      bra 0x2340 <mjrty+48>
0x2334 <mjrty+36>:      cmpl 0(a0)[d0.l*4],d3
0x2338 <mjrty+40>:      bne 0x233e <mjrty+46>
0x233a <mjrty+42>:      addql #1,d1
0x233c <mjrty+44>:      bra 0x2340 <mjrty+48>
0x233e <mjrty+46>:      subl #1,d1
0x2340 <mjrty+48>:      addql #1,d0
0x2342 <mjrty+50>:      cmpl d0,d2
0x2344 <mjrty+52>:      bgt 0x2328 <mjrty+24>
0x2346 <mjrty+54>:      movel d3,d4
0x2348 <mjrty+56>:      tstl d1
0x234a <mjrty+58>:      beq 0x2382 <mjrty+114>
0x234c <mjrty+60>:      movel d2,d0
0x234e <mjrty+62>:      bge 0x2352 <mjrty+66>
0x2350 <mjrty+64>:      addql #1,d0
0x2352 <mjrty+66>:      asrl #1,d0
0x2354 <mjrty+68>:      cmpl d1,d0
0x2356 <mjrty+70>:      bge 0x235c <mjrty+76>
0x2358 <mjrty+72>:      movel #1,d5
0x235a <mjrty+74>:      bra 0x2384 <mjrty+116>
0x235c <mjrty+76>:      clrl d1
0x235e <mjrty+78>:      clrl d0
0x2360 <mjrty+80>:      cmpl d0,d2
0x2362 <mjrty+82>:      ble 0x2372 <mjrty+98>
0x2364 <mjrty+84>:      cmpl 0(a0)[d0.l*4],d3
0x2368 <mjrty+88>:      bne 0x236c <mjrty+92>
0x236a <mjrty+90>:      addql #1,d1
0x236c <mjrty+92>:      addql #1,d0
0x236e <mjrty+94>:      cmpl d0,d2
0x2370 <mjrty+96>:      bgt 0x2364 <mjrty+84>
0x2372 <mjrty+98>:      movel d2,d0
0x2374 <mjrty+100>:     bge 0x2378 <mjrty+104>
0x2376 <mjrty+102>:     addql #1,d0
0x2378 <mjrty+104>:     asrl #1,d0
0x237a <mjrty+106>:     cmpl d1,d0
0x237c <mjrty+108>:     bge 0x2382 <mjrty+114>
0x237e <mjrty+110>:     movel #1,d5
0x2380 <mjrty+112>:     bra 0x2384 <mjrty+116>
```

```
0x2382 <mjrty+114>:     clrl d5
0x2384 <mjrty+116>:     movel d4,d0
0x2386 <mjrty+118>:     movel d5,d1
0x2388 <mjrty+120>:     moveml a6@(-16),d2-d5
0x238e <mjrty+126>:     unlk a6
0x2390 <mjrty+128>:     rts
```

The machine code of the above program is:

```
<mjrty>:      0x4e56  0x0000  0x48e7  0x3c00  0x206e  0x0008  0x242e  0x000c
<mjrty+16>:   0x4281  0x4280  0xb480  0x6f1e  0x4a81  0x6608  0x2630  0x0c00
<mjrty+32>:   0x7201  0x600c  0xb6b0  0x0c00  0x6604  0x5281  0x6002  0x5381
<mjrty+48>:   0x5280  0xb480  0x6ee2  0x2803  0x4a81  0x6736  0x2002  0x6c02
<mjrty+64>:   0x5280  0xe280  0xb081  0x6c04  0x7a01  0x6028  0x4281  0x4280
<mjrty+80>:   0xb480  0x6f0e  0xb6b0  0x0c00  0x6602  0x5281  0x5280  0xb480
<mjrty+96>:   0x6ef2  0x2002  0x6c02  0x5280  0xe280  0xb081  0x6c04  0x7a01
<mjrty+112>:  0x6002  0x4285  0x2004  0x2205  0x4cee  0x003c  0xfff0  0x4e5e
<mjrty+128>:  0x4e75
```

In the Nqthm logic, it is like:

```
'(78      86      0       0       72      231     60      0
  32      110     0       8       36      46      0       12
  66      129     66      128     180     128     111     30
  74      129     102     8       38      48      12      0
  114     1       96      12      182     176     12      0
  102     4       82      129     96      2       83      129
  82      128     180     128     110     226     40      3
  74      129     103     54      32      2       108     2
  82      128     226     128     176     129     108     4
  122     1       96      40      66      129     66      128
  180     128     111     14      182     176     12      0
  102     2       82      129     82      128     180     128
  110     242     32      2       108     2       82      128
  226     128     176     129     108     4       122     1
  96      2       66      133     32      4       34      5
  76      238     0       60      255     240     78      94
  78      117)
|#
```

```
; in the logic, the above program is defined by (mjrty-code).
```

DEFINITION:

MJRTY-CODE

```
=  '(78 86 0 0 72 231 60 0 32 110 0 8 36 46 0 12 66 129
    66 128 180 128 111 30 74 129 102 8 38 48 12 0 114 1
    96 12 182 176 12 0 102 4 82 129 96 2 83 129 82 128
    180 128 110 226 40 3 74 129 103 54 32 2 108 2 82 128
    226 128 176 129 108 4 122 1 96 40 66 129 66 128 180
    128 111 14 182 176 12 0 102 2 82 129 82 128 180 128
    110 242 32 2 108 2 82 128 226 128 176 129 108 4 122
    1 96 2 66 133 32 4 34 5 76 238 0 60 255 240 78 94 78
    117)

; mjrty-cand is a function in the logic to simulate the candidate
; findhe above code.
```

DEFINITION:
mjrty-cand $(n,\ lst,\ cand,\ i,\ k)$
$=$ **if** $i < n$
then if $k \simeq 0$ **then** mjrty-cand $(n,\ lst,$ get-nth $(i,\ lst),\ 1 + i,\ 1)$
elseif $cand =$ get-nth $(i,\ lst)$
then mjrty-cand $(n,\ lst,\ cand,\ 1 + i,\ 1 + k)$
else mjrty-cand $(n,\ lst,\ cand,\ 1 + i,\ k - 1)$ **endif**
else *cand* **endif**

DEFINITION:
mjrty-k $(n,\ lst,\ cand,\ i,\ k)$
$=$ **if** $i < n$
then if $k \simeq 0$ **then** mjrty-k $(n,\ lst,$ get-nth $(i,\ lst),\ 1 + i,\ 1)$
elseif $cand =$ get-nth $(i,\ lst)$
then mjrty-k $(n,\ lst,\ cand,\ 1 + i,\ 1 + k)$
else mjrty-k $(n,\ lst,\ cand,\ 1 + i,\ k - 1)$ **endif**
else k **endif**

```
; cand-cnt is a function in the logic to simulate the process of
; counting the number of votes for the given candidate.
```

DEFINITION:
cand-cnt $(n,\ lst,\ cand,\ i,\ k)$
$=$ **if** $i < n$
then if $cand =$ get-nth $(i,\ lst)$ **then** cand-cnt $(n,\ lst,\ cand,\ 1 + i,\ 1 + k)$
else cand-cnt $(n,\ lst,\ cand,\ 1 + i,\ k)$ **endif**
else k **endif**

```
; mjrty-p determines if the given candidate cand has received a majority
; voting.
```

DEFINITION:
mjrty-p (*n*, *lst*, *cand*, *i*, *k*)
= **if** mjrty-k (*n*, *lst*, *cand*, *i*, *k*) ≃ 0 **then f**
elseif (*n* ÷ 2) < mjrty-k (*n*, *lst*, *cand*, *i*, *k*) **then t**
else (*n* ÷ 2)
< cand-cnt (*n*, *lst*, mjrty-cand (*n*, *lst*, *cand*, *i*, *k*), *i*, *k*) **endif**

; the computation time.

DEFINITION:
mjrty-cand-t (*a*, *n*, *lst*, *cand*, *i*, *k*)
= **if** *i* < *n*
then if *k* ≃ 0
then let *cand1* **be** get-nth (*i*, *lst*)
in
splus (8, mjrty-cand-t (*a*, *n*, *lst*, *cand1*, 1 + *i*, 1)) **endlet**
elseif *cand* = get-nth (*i*, *lst*)
then splus (9, mjrty-cand-t (*a*, *n*, *lst*, *cand*, 1 + *i*, 1 + *k*))
else splus (8, mjrty-cand-t (*a*, *n*, *lst*, *cand*, 1 + *i*, *k* − 1)) **endif**
elseif *cand* = get-nth (0, *lst*) **then** 18
else 17 **endif**

DEFINITION:
mjrty-sn-t (*a*, *n*, *lst*, *cand*, *i*, *k*)
= **if** *i* < *n*
then if *k* ≃ 0
then let *cand1* **be** get-nth (*i*, *lst*)
in
splus (8, mjrty-sn-t (*a*, *n*, *lst*, *cand1*, 1 + *i*, 1)) **endlet**
elseif *cand* = get-nth (*i*, *lst*)
then splus (9, mjrty-sn-t (*a*, *n*, *lst*, *cand*, 1 + *i*, 1 + *k*))
else splus (8, mjrty-sn-t (*a*, *n*, *lst*, *cand*, 1 + *i*, *k* − 1)) **endif**
elseif *k* ≃ 0 **then** 11
else 17 **endif**

DEFINITION:
cand-cnt-t (*a*, *n*, *lst*, *cand*, *i*, *k*)
= **if** *i* < *n*
then if *cand* = get-nth (*i*, *lst*)
then splus (6, cand-cnt-t (*a*, *n*, *lst*, *cand*, 1 + *i*, 1 + *k*))
else splus (5, cand-cnt-t (*a*, *n*, *lst*, *cand*, 1 + *i*, *k*)) **endif**
elseif (*n* ÷ 2) < *k* **then** 14
else 13 **endif**

DEFINITION:

```
mjrty-t (a, n, lst)
=   let cand be get-nth (0, lst)
    in
    splus (14,
           if (mjrty-k (n, lst, cand, 1, 1) ≃ 0)
              ∨   ((n ÷ 2) < mjrty-k (n, lst, cand, 1, 1))
           then mjrty-sn-t (a, n, lst, cand, 1, 1)
           else splus (mjrty-cand-t (a, n, lst, cand, 1, 1),
                       if cand = mjrty-cand (n, lst, cand, 1, 1)
                       then cand-cnt-t (a,
                                        n,
                                        lst,
                                        mjrty-cand (n,
                                                    lst,
                                                    cand,
                                                    1,
                                                    1),
                                        1,
                                        1)
                       else cand-cnt-t (a,
                                        n,
                                        lst,
                                        mjrty-cand (n,
                                                    lst,
                                                    cand,
                                                    1,
                                                    1),
                                        1,
                                        0) endif) endif) endlet

; induction hints.

DEFINITION:
mjrty-cand-induct (s, n, lst, cand, i, k)
=   if i < n
    then if k ≃ 0
         then let cand1 be get-nth (i, lst)
              in
              mjrty-cand-induct (stepn (s, 8), n, lst, cand1, 1 + i, 1) endlet
         elseif cand = get-nth (i, lst)
         then mjrty-cand-induct (stepn (s, 9), n, lst, cand, 1 + i, 1 + k)
         else mjrty-cand-induct (stepn (s, 8), n, lst, cand, 1 + i, k − 1) endif
    else t endif

DEFINITION:
```

```
cand-cnt-induct (s, n, lst, cand, i, k)
=   if i < n
    then if cand = get-nth (i, lst)
             then cand-cnt-induct (stepn (s, 6), n, lst, cand, 1 + i, 1 + k)
             else cand-cnt-induct (stepn (s, 5), n, lst, cand, 1 + i, k) endif
    else t endif

; the preconditions of the initial state.
```

DEFINITION:

```
mjrty-statep (s, a, n, lst)
=   ((mc-status (s) = 'running)
     ∧  evenp (mc-pc (s))
     ∧  rom-addrp (mc-pc (s), mc-mem (s), 130)
     ∧  mcode-addrp (mc-pc (s), mc-mem (s), MJRTY-CODE)
     ∧  ram-addrp (sub (32, 20, read-sp (s)), mc-mem (s), 32)
     ∧  ram-addrp (a, mc-mem (s), 4 * n)
     ∧  mem-ilst (4, a, mc-mem (s), n, lst)
     ∧  disjoint (a, 4 * n, sub (32, 20, read-sp (s)), 32)
     ∧  (a = read-mem (add (32, read-sp (s), 4), mc-mem (s), 4))
     ∧  (n = iread-mem (add (32, read-sp (s), 8), mc-mem (s), 4))
     ∧  (n ≠ 0))

; the conditions of the intermediate state s0.
```

DEFINITION:

```
mjrty-s0p (s, a, n, lst, cand, i, k)
=   ((mc-status (s) = 'running)
     ∧  evenp (mc-pc (s))
     ∧  rom-addrp (sub (32, 50, mc-pc (s)), mc-mem (s), 130)
     ∧  mcode-addrp (sub (32, 50, mc-pc (s)), mc-mem (s), MJRTY-CODE)
     ∧  ram-addrp (sub (32, 16, read-an (32, 6, s)), mc-mem (s), 32)
     ∧  ram-addrp (a, mc-mem (s), 4 * n)
     ∧  mem-ilst (4, a, mc-mem (s), n, lst)
     ∧  disjoint (a, 4 * n, sub (32, 16, read-an (32, 6, s)), 32)
     ∧  (a = read-rn (32, 8, mc-rfile (s)))
     ∧  (n = nat-to-int (read-rn (32, 2, mc-rfile (s)), 32))
     ∧  (cand = nat-to-int (read-rn (32, 3, mc-rfile (s)), 32))
     ∧  (i = nat-to-int (read-rn (32, 0, mc-rfile (s)), 32))
     ∧  (k = nat-to-int (read-rn (32, 1, mc-rfile (s)), 32))
     ∧  (n ≠ 0)
     ∧  (i ∈ N)
     ∧  (k ∈ N)
     ∧  (k ≤ i))
```

```
; the conditions of the intermediate state s1.
```

DEFINITION:
mjrty-s1p (s, a, n, *lst*, *cand*, i, k)
= ((mc-status (s) = 'running)
∧ evenp (mc-pc (s))
∧ rom-addrp (sub (32, 94, mc-pc (s)), mc-mem (s), 130)
∧ mcode-addrp (sub (32, 94, mc-pc (s)), mc-mem (s), MJRTY-CODE)
∧ ram-addrp (sub (32, 16, read-an (32, 6, s)), mc-mem (s), 32)
∧ ram-addrp (a, mc-mem (s), 4 ∗ n)
∧ mem-ilst (4, a, mc-mem (s), n, *lst*)
∧ disjoint (a, 4 ∗ n, sub (32, 16, read-an (32, 6, s)), 32)
∧ (a = read-rn (32, 8, mc-rfile (s)))
∧ (n = nat-to-int (read-rn (32, 2, mc-rfile (s)), 32))
∧ (*cand* = nat-to-int (read-rn (32, 4, mc-rfile (s)), 32))
∧ (*cand* = nat-to-int (read-rn (32, 3, mc-rfile (s)), 32))
∧ (i = nat-to-int (read-rn (32, 0, mc-rfile (s)), 32))
∧ (k = nat-to-int (read-rn (32, 1, mc-rfile (s)), 32))
∧ ($n \not\simeq$ 0)
∧ ($i \in \mathbf{N}$)
∧ ($k \in \mathbf{N}$)
∧ ($k \leq i$))

```
; the initial segment.  From the initial state to s0.
```

THEOREM: mjrty-s-s0
let *cand* **be** get-nth (0, *lst*)
in
mjrty-statep (s, a, n, *lst*)
→ (mjrty-s0p (stepn (s, 14), a, n, *lst*, *cand*, 1, 1)
∧ (linked-rts-addr (stepn (s, 14)) = rts-addr (s))
∧ (linked-a6 (stepn (s, 14)) = read-an (32, 6, s))
∧ (read-rn (32, 14, mc-rfile (stepn (s, 14)))
= sub (32, 4, read-sp (s)))
∧ (movem-saved (stepn (s, 14), 4, 16, 4)
= readm-rn (32, '(2 3 4 5), mc-rfile (s)))) **endlet**

THEOREM: mjrty-s-s0-rfile
(mjrty-statep (s, a, n, *lst*) ∧ d6-7a2-5p (*rn*))
→ (read-rn (*oplen*, *rn*, mc-rfile (stepn (s, 14)))
= read-rn (*oplen*, *rn*, mc-rfile (s)))

THEOREM: mjrty-s-s0-mem
(mjrty-statep (s, a, n, *lst*) ∧ disjoint (sub (32, 20, read-sp (s)), 32, x, k))
→ (read-mem (x, mc-mem (stepn (s, 14)), k) = read-mem (x, mc-mem (s), k))

```
; s0 --> exit.
; base case.
```

THEOREM: mjrty-s0-sn-base-1
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*) ∧ (*i* ⋠ *n*) ∧ (*k* ≃ 0))
→ ((mc-status (stepn (*s*, 11)) = 'running)
∧ (mc-pc (stepn (*s*, 11)) = linked-rts-addr (*s*))
∧ (iread-dn (32, 0, stepn (*s*, 11)) = *cand*)
∧ (iread-dn (32, 1, stepn (*s*, 11)) = 0)
∧ (read-rn (32, 14, mc-rfile (stepn (*s*, 11))) = linked-a6 (*s*))
∧ (read-rn (32, 15, mc-rfile (stepn (*s*, 11)))
= add (32, read-an (32, 6, *s*), 8))
∧ (read-mem (*x*, mc-mem (stepn (*s*, 11)), *l*)
= read-mem (*x*, mc-mem (*s*), *l*)))

THEOREM: mjrty-s0-sn-base-2
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)
∧ (*i* ⋠ *n*)
∧ (*k* ⋡ 0)
∧ ((*n* ÷ 2) < *k*))
→ ((mc-status (stepn (*s*, 17)) = 'running)
∧ (mc-pc (stepn (*s*, 17)) = linked-rts-addr (*s*))
∧ (iread-dn (32, 0, stepn (*s*, 17)) = *cand*)
∧ (iread-dn (32, 1, stepn (*s*, 17)) = 1)
∧ (read-rn (32, 14, mc-rfile (stepn (*s*, 17))) = linked-a6 (*s*))
∧ (read-rn (32, 15, mc-rfile (stepn (*s*, 17)))
= add (32, read-an (32, 6, *s*), 8))
∧ (read-mem (*x*, mc-mem (stepn (*s*, 17)), *l*)
= read-mem (*x*, mc-mem (*s*), *l*)))

THEOREM: mjrty-s0-sn-rfile-base-1
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)
∧ (*i* ⋠ *n*)
∧ (*k* ≃ 0)
∧ d2-7a2-5p (*rn*)
∧ (*oplen* ≤ 32))
→ (read-rn (*oplen*, *rn*, mc-rfile (stepn (*s*, 11)))
= **if** d6-7a2-5p (*rn*) **then** read-rn (*oplen*, *rn*, mc-rfile (*s*))
else get-vlst (*oplen*,
0,
rn,
'(2 3 4 5),
movem-saved (*s*, 4, 16, 4)) **endif**)

THEOREM: mjrty-s0-sn-rfile-base-2

(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)
 ∧ (*i* ⋠ *n*)
 ∧ (*k* ⋡ 0)
 ∧ ((*n* ÷ 2) < *k*)
 ∧ d2-7a2-5p (*rn*)
 ∧ (*oplen* ≤ 32))
→ (read-rn (*oplen*, *rn*, mc-rfile (stepn (*s*, 17)))
 = **if** d6-7a2-5p (*rn*) **then** read-rn (*oplen*, *rn*, mc-rfile (*s*))
 else get-vlst (*oplen*,
 0,
 rn,
 '(2 3 4 5),
 movem-saved (*s*, 4, 16, 4)) **endif**)

```
; induction case.
```

THEOREM: add1-int-rangep
(*x* < nat-to-int (*y*, *n*)) → int-rangep (1 + *x*, *n*)

EVENT: Enable iplus.

THEOREM: mjrty-s0-s0-1
let *cand1* **be** get-nth (*i*, *lst*)
in
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*) ∧ (*i* < *n*) ∧ (*k* ≃ 0))
→ (mjrty-s0p (stepn (*s*, 8), *a*, *n*, *lst*, *cand1*, 1 + *i*, 1)
 ∧ (linked-rts-addr (stepn (*s*, 8)) = linked-rts-addr (*s*))
 ∧ (linked-a6 (stepn (*s*, 8)) = linked-a6 (*s*))
 ∧ (read-rn (32, 14, mc-rfile (stepn (*s*, 8)))
 = read-rn (32, 14, mc-rfile (*s*)))
 ∧ (movem-saved (stepn (*s*, 8), 4, 16, 4)
 = movem-saved (*s*, 4, 16, 4))
 ∧ (read-mem (*x*, mc-mem (stepn (*s*, 8)), *l*)
 = read-mem (*x*, mc-mem (*s*), *l*))) **endlet**

THEOREM: add1-int-rangepxx
((*i* ≤ *r*) ∧ (*r* < *n*) ∧ int-rangep (*n*, 32)) → int-rangep (1 + *i*, 32)

THEOREM: mjrty-s0-s0-2
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)
 ∧ (*i* < *n*)
 ∧ (*k* ⋡ 0)
 ∧ (*cand* = get-nth (*i*, *lst*)))
→ (mjrty-s0p (stepn (*s*, 9), *a*, *n*, *lst*, *cand*, 1 + *i*, 1 + *k*)

$\wedge$ (linked-rts-addr (stepn (s, 9)) = linked-rts-addr (s))
$\wedge$ (linked-a6 (stepn (s, 9)) = linked-a6 (s))
$\wedge$ (read-rn (32, 14, mc-rfile (stepn (s, 9)))
= read-rn (32, 14, mc-rfile (s)))
$\wedge$ (movem-saved (stepn (s, 9), 4, 16, 4) = movem-saved (s, 4, 16, 4))
$\wedge$ (read-mem (x, mc-mem (stepn (s, 9)), l)
= read-mem (x, mc-mem (s), l)))

THEOREM: mjrty-s0-s0-3
(mjrty-s0p (s, a, n, *lst*, *cand*, i, k)
$\wedge$ ($i < n$)
$\wedge$ ($k \not\simeq 0$)
$\wedge$ (*cand* $\neq$ get-nth (i, *lst*)))
$\rightarrow$ (mjrty-s0p (stepn (s, 8), a, n, *lst*, *cand*, $1 + i$, $k - 1$)
$\wedge$ (linked-rts-addr (stepn (s, 8)) = linked-rts-addr (s))
$\wedge$ (linked-a6 (stepn (s, 8)) = linked-a6 (s))
$\wedge$ (read-rn (32, 14, mc-rfile (stepn (s, 8)))
= read-rn (32, 14, mc-rfile (s)))
$\wedge$ (movem-saved (stepn (s, 8), 4, 16, 4) = movem-saved (s, 4, 16, 4))
$\wedge$ (read-mem (x, mc-mem (stepn (s, 8)), l)
= read-mem (x, mc-mem (s), l)))

THEOREM: mjrty-s0-s0-rfile-1
(mjrty-s0p (s, a, n, *lst*, *cand*, i, k) $\wedge$ ($i < n$) $\wedge$ ($k \simeq 0$) $\wedge$ d6-7a2-5p (*rn*))
$\rightarrow$ (read-rn (*oplen*, *rn*, mc-rfile (stepn (s, 8)))
= read-rn (*oplen*, *rn*, mc-rfile (s)))

THEOREM: mjrty-s0-s0-rfile-2
(mjrty-s0p (s, a, n, *lst*, *cand*, i, k)
$\wedge$ ($i < n$)
$\wedge$ ($k \not\simeq 0$)
$\wedge$ (*cand* = get-nth (i, *lst*))
$\wedge$ d6-7a2-5p (*rn*))
$\rightarrow$ (read-rn (*oplen*, *rn*, mc-rfile (stepn (s, 9)))
= read-rn (*oplen*, *rn*, mc-rfile (s)))

THEOREM: mjrty-s0-s0-rfile-3
(mjrty-s0p (s, a, n, *lst*, *cand*, i, k)
$\wedge$ ($i < n$)
$\wedge$ ($k \not\simeq 0$)
$\wedge$ (*cand* $\neq$ get-nth (i, *lst*))
$\wedge$ d6-7a2-5p (*rn*))
$\rightarrow$ (read-rn (*oplen*, *rn*, mc-rfile (stepn (s, 8)))
= read-rn (*oplen*, *rn*, mc-rfile (s)))

```
; the proof of s0 --> exit.
```

THEOREM: mjrty-s0-sn
let *sn* **be** stepn (*s*, mjrty-sn-t (*a*, *n*, *lst*, *cand*, *i*, *k*))
in
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)
 ∧ ((mjrty-k (*n*, *lst*, *cand*, *i*, *k*) ≃ 0)
  ∨ ((*n* ÷ 2) < mjrty-k (*n*, *lst*, *cand*, *i*, *k*))))
→ ((mc-status (*sn*) = 'running)
  ∧ (mc-pc (*sn*) = linked-rts-addr (*s*))
  ∧ (iread-dn (32, 0, *sn*) = mjrty-cand (*n*, *lst*, *cand*, *i*, *k*))
  ∧ (iread-dn (32, 1, *sn*)
    = **if** (*n* ÷ 2) < mjrty-k (*n*, *lst*, *cand*, *i*, *k*)
      then 1
      else 0 **endif**)
  ∧ (read-rn (32, 14, mc-rfile (*sn*)) = linked-a6 (*s*))
  ∧ (read-rn (32, 15, mc-rfile (*sn*))
    = add (32, read-an (32, 6, *s*), 8))
  ∧ (read-mem (*x*, mc-mem (*sn*), *l*) = read-mem (*x*, mc-mem (*s*), *l*))) **endlet**

THEOREM: mjrty-s0-sn-rfile
let *sn* **be** stepn (*s*, mjrty-sn-t (*a*, *n*, *lst*, *cand*, *i*, *k*))
in
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)
 ∧ ((mjrty-k (*n*, *lst*, *cand*, *i*, *k*) ≃ 0)
  ∨ ((*n* ÷ 2) < mjrty-k (*n*, *lst*, *cand*, *i*, *k*)))
 ∧ d2-7a2-5p (*rn*)
 ∧ (*oplen* ≤ 32))
→ (read-rn (*oplen*, *rn*, mc-rfile (*sn*))
  = **if** d6-7a2-5p (*rn*) **then** read-rn (*oplen*, *rn*, mc-rfile (*s*))
    else get-vlst (*oplen*,
                       0,
                       rn,
                       '(2 3 4 5),
                       movem-saved (*s*, 4, 16, 4)) **endif**) **endlet**

```
; s0 --> s1.
; base case:
```

THEOREM: mjrty-s0-s1-base1
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)
 ∧ (*i* ≮ *n*)
 ∧ (*k* ≯ 0)
 ∧ ((*n* ÷ 2) ≮ *k*)
 ∧ (*cand* = get-nth (0, *lst*)))

$\rightarrow$ (mjrty-s1p (stepn (s, 18), a, n, lst, $cand$, 1, 1)
$\wedge$ (linked-rts-addr (stepn (s, 18)) = linked-rts-addr (s))
$\wedge$ (linked-a6 (stepn (s, 18)) = linked-a6 (s))
$\wedge$ (read-rn (32, 14, mc-rfile (stepn (s, 18)))
= read-rn (32, 14, mc-rfile (s)))
$\wedge$ (movem-saved (stepn (s, 18), 4, 16, 4) = movem-saved (s, 4, 16, 4))
$\wedge$ (read-mem (x, mc-mem (stepn (s, 18)), l)
= read-mem (x, mc-mem (s), l)))

THEOREM: mjrty-s0-s1-base2
(mjrty-s0p (s, a, n, lst, $cand$, i, k)
$\wedge$ ($i \not< n$)
$\wedge$ ($k \not\geq 0$)
$\wedge$ ($(n \div 2) \not< k$)
$\wedge$ ($cand \neq$ get-nth (0, lst)))
$\rightarrow$ (mjrty-s1p (stepn (s, 17), a, n, lst, $cand$, 1, 0)
$\wedge$ (linked-rts-addr (stepn (s, 17)) = linked-rts-addr (s))
$\wedge$ (linked-a6 (stepn (s, 17)) = linked-a6 (s))
$\wedge$ (read-rn (32, 14, mc-rfile (stepn (s, 17)))
= read-rn (32, 14, mc-rfile (s)))
$\wedge$ (movem-saved (stepn (s, 17), 4, 16, 4) = movem-saved (s, 4, 16, 4))
$\wedge$ (read-mem (x, mc-mem (stepn (s, 17)), l)
= read-mem (x, mc-mem (s), l)))

THEOREM: mjrty-s0-s1-rfile-base1
(mjrty-s0p (s, a, n, lst, $cand$, i, k)
$\wedge$ ($i \not< n$)
$\wedge$ ($k \not\geq 0$)
$\wedge$ ($(n \div 2) \not< k$)
$\wedge$ ($cand =$ get-nth (0, lst))
$\wedge$ d6-7a2-5p (rn))
$\rightarrow$ (read-rn ($oplen$, rn, mc-rfile (stepn (s, 18)))
= read-rn ($oplen$, rn, mc-rfile (s)))

THEOREM: mjrty-s0-s1-rfile-base2
(mjrty-s0p (s, a, n, lst, $cand$, i, k)
$\wedge$ ($i \not< n$)
$\wedge$ ($k \not\geq 0$)
$\wedge$ ($(n \div 2) \not< k$)
$\wedge$ ($cand \neq$ get-nth (0, lst))
$\wedge$ d6-7a2-5p (rn))
$\rightarrow$ (read-rn ($oplen$, rn, mc-rfile (stepn (s, 17)))
= read-rn ($oplen$, rn, mc-rfile (s)))

```
; the proof of s0 --> s1.
```

THEOREM: mjrty-s0-s1
let *s1* **be** stepn (*s*, mjrty-cand-t (*a*, *n*, *lst*, *cand*, *i*, *k*))
in
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)
 ∧ (mjrty-k (*n*, *lst*, *cand*, *i*, *k*) ≠ 0)
 ∧ ((*n* ÷ 2) ≮ mjrty-k (*n*, *lst*, *cand*, *i*, *k*))
 ∧ (*cand0* = mjrty-cand (*n*, *lst*, *cand*, *i*, *k*))
 ∧ (*k0* = **if** mjrty-cand (*n*, *lst*, *cand*, *i*, *k*) = get-nth (0, *lst*)
 then 1
 else 0 **endif**))
→ (mjrty-s1p (*s1*, *a*, *n*, *lst*, *cand0*, 1, *k0*)
 ∧ (linked-rts-addr (*s1*) = linked-rts-addr (*s*))
 ∧ (linked-a6 (*s1*) = linked-a6 (*s*))
 ∧ (read-rn (32, 14, mc-rfile (*s1*))
 = read-rn (32, 14, mc-rfile (*s*)))
 ∧ (movem-saved (*s1*, 4, 16, 4) = movem-saved (*s*, 4, 16, 4))
 ∧ (read-mem (*x*, mc-mem (*s1*), *l*) = read-mem (*x*, mc-mem (*s*), *l*))) **endlet**

THEOREM: mjrty-s0-s1-rfile
let *s1* **be** stepn (*s*, mjrty-cand-t (*a*, *n*, *lst*, *cand*, *i*, *k*))
in
(mjrty-s0p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)
 ∧ (mjrty-k (*n*, *lst*, *cand*, *i*, *k*) ≠ 0)
 ∧ ((*n* ÷ 2) ≮ mjrty-k (*n*, *lst*, *cand*, *i*, *k*))
 ∧ d6-7a2-5p (*rn*))
→ (read-rn (*oplen*, *rn*, mc-rfile (*s1*))
 = read-rn (*oplen*, *rn*, mc-rfile (*s*))) **endlet**

```
; s1 --> exit.
; base case.
```

THEOREM: mjrty-s1-sn-1
(mjrty-s1p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*) ∧ (*i* ≮ *n*) ∧ ((*n* ÷ 2) < *k*))
→ ((mc-status (stepn (*s*, 14)) = 'running)
 ∧ (mc-pc (stepn (*s*, 14)) = linked-rts-addr (*s*))
 ∧ (iread-dn (32, 0, stepn (*s*, 14)) = *cand*)
 ∧ (iread-dn (32, 1, stepn (*s*, 14)) = 1)
 ∧ (read-rn (32, 14, mc-rfile (stepn (*s*, 14))) = linked-a6 (*s*))
 ∧ (read-rn (32, 15, mc-rfile (stepn (*s*, 14)))
 = add (32, read-an (32, 6, *s*), 8))
 ∧ (read-mem (*x*, mc-mem (stepn (*s*, 14)), *l*)
 = read-mem (*x*, mc-mem (*s*), *l*)))

THEOREM: mjrty-s1-sn-rfile-1
(mjrty-s1p (*s*, *a*, *n*, *lst*, *cand*, *i*, *k*)

$\wedge$ $(i \not< n)$
$\wedge$ $((n \div 2) < k)$
$\wedge$ d2-7a2-5p (rn)
$\wedge$ $(oplen \leq 32)$)
$\rightarrow$ (read-rn $(oplen,\ rn,$ mc-rfile (stepn $(s,\ 14)$))
= **if** d6-7a2-5p (rn) **then** read-rn $(oplen,\ rn,$ mc-rfile $(s))$
else get-vlst $(oplen,$
0,
rn,
'(2 3 4 5),
movem-saved $(s,\ 4,\ 16,\ 4))$ **endif**)

THEOREM: mjrty-s1-sn-2
(mjrty-s1p $(s,\ a,\ n,\ lst,\ cand,\ i,\ k) \wedge (i \not< n) \wedge ((n \div 2) \not< k)$)
$\rightarrow$ ((mc-status (stepn $(s,\ 13)$) = 'running)
$\wedge$ (mc-pc (stepn $(s,\ 13)$) = linked-rts-addr (s))
$\wedge$ (iread-dn $(32,\ 0,$ stepn $(s,\ 13)) = cand$)
$\wedge$ (iread-dn $(32,\ 1,$ stepn $(s,\ 13)) = 0$)
$\wedge$ (read-rn $(32,\ 14,$ mc-rfile (stepn $(s,\ 13))) =$ linked-a6 (s))
$\wedge$ (read-rn $(32,\ 15,$ mc-rfile (stepn $(s,\ 13))$)
= add $(32,$ read-an $(32,\ 6,\ s),\ 8)$)
$\wedge$ (read-mem $(x,$ mc-mem (stepn $(s,\ 13)),\ l$)
= read-mem $(x,$ mc-mem $(s),\ l)$))

THEOREM: mjrty-s1-sn-rfile-2
(mjrty-s1p $(s,\ a,\ n,\ lst,\ cand,\ i,\ k)$
$\wedge$ $(i \not< n)$
$\wedge$ $((n \div 2) \not< k)$
$\wedge$ d2-7a2-5p (rn)
$\wedge$ $(oplen \leq 32)$)
$\rightarrow$ (read-rn $(oplen,\ rn,$ mc-rfile (stepn $(s,\ 13)$))
= **if** d6-7a2-5p (rn) **then** read-rn $(oplen,\ rn,$ mc-rfile $(s))$
else get-vlst $(oplen,$
0,
rn,
'(2 3 4 5),
movem-saved $(s,\ 4,\ 16,\ 4))$ **endif**)

```
; induction case.
```

THEOREM: mjrty-s1-s1-1
(mjrty-s1p $(s,\ a,\ n,\ lst,\ cand,\ i,\ k) \wedge (i < n) \wedge (cand =$ get-nth $(i,\ lst)$))
$\rightarrow$ (mjrty-s1p (stepn $(s,\ 6),\ a,\ n,\ lst,\ cand,\ 1 + i,\ 1 + k$)
$\wedge$ (linked-rts-addr (stepn $(s,\ 6)$) = linked-rts-addr (s))
$\wedge$ (linked-a6 (stepn $(s,\ 6)$) = linked-a6 (s))

$\wedge$ (read-rn (32, 14, mc-rfile (stepn (s, 6)))
= read-rn (32, 14, mc-rfile (s)))
$\wedge$ (movem-saved (stepn (s, 6), 4, 16, 4) = movem-saved (s, 4, 16, 4))
$\wedge$ (read-mem (x, mc-mem (stepn (s, 6)), l)
= read-mem (x, mc-mem (s), l)))

THEOREM: mjrty-s1-s1-2
(mjrty-s1p (s, a, n, lst, $cand$, i, k) $\wedge$ ($i < n$) $\wedge$ ($cand \neq$ get-nth (i, lst)))
$\rightarrow$ (mjrty-s1p (stepn (s, 5), a, n, lst, $cand$, $1 + i$, k)
$\wedge$ (linked-rts-addr (stepn (s, 5)) = linked-rts-addr (s))
$\wedge$ (linked-a6 (stepn (s, 5)) = linked-a6 (s))
$\wedge$ (read-rn (32, 14, mc-rfile (stepn (s, 5)))
= read-rn (32, 14, mc-rfile (s)))
$\wedge$ (movem-saved (stepn (s, 5), 4, 16, 4) = movem-saved (s, 4, 16, 4))
$\wedge$ (read-mem (x, mc-mem (stepn (s, 5)), l)
= read-mem (x, mc-mem (s), l)))

THEOREM: mjrty-s1-s1-rfile-1
(mjrty-s1p (s, a, n, lst, $cand$, i, k)
$\wedge$ ($i < n$)
$\wedge$ ($cand$ = get-nth (i, lst))
$\wedge$ d6-7a2-5p (rn))
$\rightarrow$ (read-rn ($oplen$, rn, mc-rfile (stepn (s, 6)))
= read-rn ($oplen$, rn, mc-rfile (s)))

THEOREM: mjrty-s1-s1-rfile-2
(mjrty-s1p (s, a, n, lst, $cand$, i, k)
$\wedge$ ($i < n$)
$\wedge$ ($cand \neq$ get-nth (i, lst))
$\wedge$ d6-7a2-5p (rn))
$\rightarrow$ (read-rn ($oplen$, rn, mc-rfile (stepn (s, 5)))
= read-rn ($oplen$, rn, mc-rfile (s)))

THEOREM: mjrty-s1-sn
let sn **be** stepn (s, cand-cnt-t (a, n, lst, $cand$, i, k))
in
mjrty-s1p (s, a, n, lst, $cand$, i, k)
$\rightarrow$ ((mc-status (sn) = 'running)
$\wedge$ (mc-pc (sn) = linked-rts-addr (s))
$\wedge$ (iread-dn (32, 0, sn) = $cand$)
$\wedge$ (iread-dn (32, 1, sn)
= **if** ($n \div 2$) < cand-cnt (n, lst, $cand$, i, k)
then 1
else 0 **endif**)
$\wedge$ (read-rn (32, 14, mc-rfile (sn)) = linked-a6 (s))

```
    ∧   (read-rn (32, 15, mc-rfile (sn))
          =   add (32, read-an (32, 6, s), 8))
    ∧   (read-mem (x, mc-mem (sn), l) = read-mem (x, mc-mem (s), l))) endlet
```

THEOREM: mjrty-s1-sn-rfile

```
let sn be stepn (s, cand-cnt-t (a, n, lst, cand, i, k))
in
(mjrty-s1p (s, a, n, lst, cand, i, k) ∧ d2-7a2-5p (rn) ∧ (oplen ≤ 32))
→   (read-rn (oplen, rn, mc-rfile (sn))
      =   if d6-7a2-5p (rn) then read-rn (oplen, rn, mc-rfile (s))
          else get-vlst (oplen,
                         0,
                         rn,
                         '(2 3 4 5),
                         movem-saved (s, 4, 16, 4)) endif) endlet
```

```
; the correctness of MJRTY.
```

THEOREM: mjrty-statep-info

```
mjrty-statep (s, a, n, lst) → (n ≠ 0)
```

THEOREM: mjrty-correctness

```
let sn be stepn (s, mjrty-t (a, n, lst))
in
mjrty-statep (s, a, n, lst)
→   ((mc-status (sn) = 'running)
    ∧   (mc-pc (sn) = rts-addr (s))
    ∧   (read-rn (32, 14, mc-rfile (sn))
          =   read-rn (32, 14, mc-rfile (s)))
    ∧   (read-rn (32, 15, mc-rfile (sn))
          =   add (32, read-sp (s), 4))
    ∧   ((d2-7a2-5p (rn) ∧ (oplen ≤ 32))
          →   (read-rn (oplen, rn, mc-rfile (sn))
                =   read-rn (oplen, rn, mc-rfile (s))))
    ∧   (disjoint (sub (32, 20, read-sp (s)), 32, x, k)
          →   (read-mem (x, mc-mem (sn), k)
                =   read-mem (x, mc-mem (s), k)))
    ∧   (iread-dn (32, 0, sn) = mjrty-cand (n, lst, 0, 0, 0))
    ∧   (iread-dn (32, 1, sn)
          =   if mjrty-p (n, lst, 0, 0, 0) then 1
              else 0 endif)) endlet
```

EVENT: Disable mjrty-t.

```
; in the logic, mjrty is expected to have these properties:
```

```
;    1.  mjrty-thm-1: if mjrty-p returns 1,  cand wins the majority.
;    2.  mjrty-thm-2: if mjrty-p returns 0,  no one wins the majority.
```

THEOREM: mjrty-cand-0
mjrty-cand $(n, lst, x, n, k) = x$

THEOREM: mjrty-cand-1
mjrty-cand $(1 + n, lst, x, n, k)$
$=$ **if** $k \simeq$ `0` **then** get-nth (n, lst)
else x **endif**

THEOREM: mjrty-k-0
mjrty-k $(n, lst, x, n, k) = k$

THEOREM: mjrty-k-1
mjrty-k $(1 + n, lst, x, n, k)$
$=$ **if** $k \simeq$ `0` **then** `1`
elseif $x =$ get-nth (n, lst) **then** $1 + k$
else $k - 1$ **endif**

THEOREM: cand-cnt-0
cand-cnt $(n, lst, x, n, k) = k$

THEOREM: cand-cnt-1
cand-cnt $(1 + n, lst, x, n, k)$
$=$ **if** $x =$ get-nth (n, lst) **then** $1 + k$
else k **endif**

THEOREM: mjrty-k-lemma
$((i \leq n) \wedge (j \leq i) \wedge (i \in \mathbf{N}))$
$\rightarrow$ (mjrty-k $(n,$ $lst,$ mjrty-cand $(i,$ $lst,$ $x,$ $j,$ $k),$ $i,$ mjrty-k $(i,$ $lst,$ $x,$ $j,$ $k))$
$=$ mjrty-k $(n,$ $lst,$ $x,$ $j,$ $k))$

THEOREM: mjrty-cand-lemma
$((i \leq n) \wedge (j \leq i) \wedge (i \in \mathbf{N}))$
$\rightarrow$ (mjrty-cand $(n,$ $lst,$ mjrty-cand $(i,$ $lst,$ $x,$ $j,$ $k),$ $i,$ mjrty-k $(i,$ $lst,$ $x,$ $j,$ $k))$
$=$ mjrty-cand $(n,$ $lst,$ $x,$ $j,$ $k))$

THEOREM: cand-cnt-lemma
$((i \leq n) \wedge (j \leq i) \wedge (i \in \mathbf{N}))$
$\rightarrow$ (cand-cnt $(n,$ $lst,$ $x,$ $i,$ cand-cnt $(i,$ $lst,$ $x,$ $j,$ $k)) =$ cand-cnt $(n,$ $lst,$ $x,$ $j,$ $k))$

THEOREM: mjrty-cand-rec
$(n \in \mathbf{N})$
$\rightarrow$ (mjrty-cand $(1 + n,$ $lst,$ $x,$ `0`, `0`)
$=$ mjrty-cand $(1 + n,$

lst,
mjrty-cand $(n,\ lst,\ x,\ 0,\ 0)$,
n,
mjrty-k $(n,\ lst,\ x,\ 0,\ 0)))$

THEOREM: mjrty-k-rec
$(n \in \mathbf{N})$
$\rightarrow$ (mjrty-k $(1 + n,\ lst,\ x,\ 0,\ 0)$
$=$ mjrty-k $(1 + n,$
$lst,$
mjrty-cand $(n,\ lst,\ x,\ 0,\ 0)$,
n,
mjrty-k $(n,\ lst,\ x,\ 0,\ 0)))$

THEOREM: cand-cnt-rec
$(n \in \mathbf{N})$
$\rightarrow$ (cand-cnt $(1 + n,\ lst,\ x,\ 0,\ 0)$
$=$ cand-cnt $(1 + n,\ lst,\ x,\ n,$ cand-cnt $(n,\ lst,\ x,\ 0,\ 0)))$

EVENT: Disable mjrty-cand-lemma.

EVENT: Disable mjrty-k-lemma.

EVENT: Disable cand-cnt-lemma.

THEOREM: mjrty-lemma1
cand-cnt $(n,\ lst,$ mjrty-cand $(n,\ lst,\ 0,\ 0,\ 0),\ 0,\ 0) \not< $ mjrty-k $(n,\ lst,\ 0,\ 0,\ 0)$

DEFINITION:
mjrty-lemma2-induct $(n,\ lst,\ x)$
$=$ **if** $n \simeq 0$ **then t**
else mjrty-lemma2-induct $(n - 1,\ lst,\ x)$
$\wedge$ mjrty-lemma2-induct $(n - 1,\ lst,$ get-nth $(n - 1,\ lst))$ **endif**

THEOREM: mjrty-lemma2
$((n +$ mjrty-k $(n,\ lst,\ 0,\ 0,\ 0))$
$\not<$ $(2 *$ cand-cnt $(n,\ lst,$ mjrty-cand $(n,\ lst,\ 0,\ 0,\ 0),\ 0,\ 0)))$
$\wedge$ $((x \neq$ mjrty-cand $(n,\ lst,\ 0,\ 0,\ 0))$
$\rightarrow$ $(n \not< ($mjrty-k $(n,\ lst,\ 0,\ 0,\ 0)$
$+$ $(2 *$ cand-cnt $(n,\ lst,\ x,\ 0,\ 0)))))$

EVENT: Disable mjrty-cand-rec.

EVENT: Disable mjrty-k-rec.

EVENT: Disable cand-cnt-rec.

THEOREM: mjrty-thm1
mjrty-p (*n*, *lst*, 0, 0, 0)
→ ((*n* ÷ 2) < cand-cnt (*n*, *lst*, mjrty-cand (*n*, *lst*, 0, 0, 0), 0, 0))

THEOREM: mjrty-thm2
(¬ mjrty-p (*n*, *lst*, 0, 0, 0)) → ((*n* ÷ 2) ≮ cand-cnt (*n*, *lst*, *x*, 0, 0))

```
; a simple time analysis.
```

THEOREM: mjrty-t-crock
(*z* ∗ ((*x* − 1) − *y*)) = ((*z* ∗ (*x* − *y*)) − *z*)

THEOREM: mjrty-cand-t-0
(mjrty-cand-t (*a*, 0, *lst*, *cand*, *i*, *k*)
= **if** *cand* = get-nth (0, *lst*) **then** 18
else 17 **endif**)
∧ (mjrty-cand-t (*a*, 1, *lst*, *cand*, 1, *k*)
= **if** *cand* = get-nth (0, *lst*) **then** 18
else 17 **endif**)

THEOREM: mjrty-cand-t-1
mjrty-cand-t (*a*, 1, *lst*, *cand*, *i*, *k*)
= **if** *i* ≃ 0
then if *k* ≃ 0 **then** 26
elseif *cand* = get-nth (*i*, *lst*)
then if *cand* = get-nth (0, *lst*) **then** 27
else 26 **endif**
elseif *cand* = get-nth (0, *lst*) **then** 26
else 25 **endif**
elseif *cand* = get-nth (0, *lst*) **then** 18
else 17 **endif**

THEOREM: mjrty-cand-t-ubound
(18 + (9 ∗ (*n* − *i*))) ≮ mjrty-cand-t (*a*, *n*, *lst*, *cand*, *i*, *k*)

THEOREM: mjrty-sn-t-ubound
(17 + (9 ∗ (*n* − *i*))) ≮ mjrty-sn-t (*a*, *n*, *lst*, *cand*, *i*, *k*)

THEOREM: cand-cnt-t-0
(cand-cnt-t (*a*, 0, *lst*, *cand*, *i*, *k*)
= **if** 0 < *k* **then** 14
else 13 **endif**)
∧ (cand-cnt-t (*a*, *n*, *lst*, *cand*, *n*, *k*)
= **if** (*n* ÷ 2) < *k* **then** 14
else 13 **endif**)

THEOREM: cand-cnt-t-1
cand-cnt-t $(a,\ \texttt{1},\ lst,\ cand,\ i,\ k)$
$=$ **if** $i \simeq \texttt{0}$
then if $cand =$ get-nth $(i,\ lst)$ **then** 20
elseif $\texttt{0} < k$ **then** 19
else 18 **endif**
elseif $\texttt{0} < k$ **then** 14
else 13 **endif**

THEOREM: cand-cnt-t-ubound
$(\texttt{14} + (\texttt{6} * (n - i))) \not< \text{cand-cnt-t}\,(a,\ n,\ lst,\ cand,\ i,\ k)$

THEOREM: mjrty-t-ubound
mjrty-t $(a,\ n,\ lst) \leq (\texttt{46} + (\texttt{15} * (n - 1)))$

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