# Porting and Performance of PCM on the Cray X1

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# Acknowledgements

- ORNL consulting staff, esp. Mark Fahey
- Cray Consultants John Levesque,Ilene Carpenter
- NCAR Consultant Jeff Keuhn
- CCP Colleague Gary Strand

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# Outline

- Description and History of PCM
- Porting Process
- Preliminary Performance on X1

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# About PCM

# PCM

- PCM – Parallel Climate Model
  - Joint DOE -NCAR effort to develop a parallel climate model, 1996 - 1997
  - Major Collaborators:
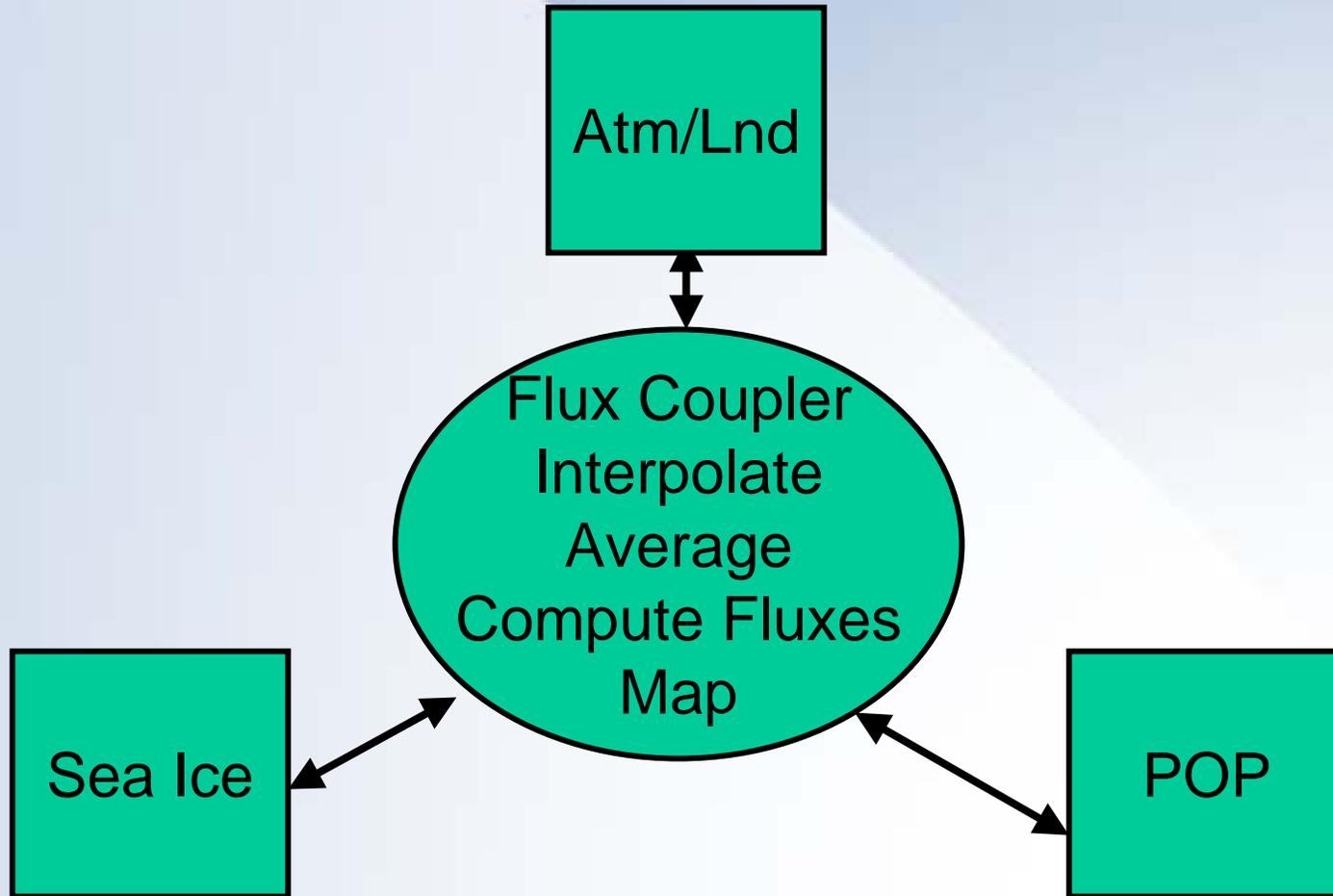    - NCAR
    - LANL
    - USNPGS
    - ORNL
    - others

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# PCM Components

- Atmosphere/Land
  - NCAR CCM3, T42 Resolution
- Ocean
  - LANL POP, 2/3 degree resolution, ½ at equator
- Ice
  - USNPGS Sea Ice Model, 27 km resolution
- NCAR Flux Coupler

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# PCM Schematic

# PCM History

- CRI T3D and SGI O2K Original targets
- Ported to:
  - Cray T3E
  - IBM Power 2,3,4
  - HP, nee Compaq, nee DEC Alpha Cluster
  - HP Precision Cluster
- Components Upgraded, RTM added,SHMEM replaced by MPI

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# PCM Usage

- ~185 cases/experiments run
- ~21000 simulated climate years
- ~100 TB data archived

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# PORTING

# Porting PCM to Cray X1

- PCM Source
  - Mainly Fortran 77, some Fortran 90
  - Lots of Previous Ports, Has been Flint-ed
  - A few C routines
  - Max of 64 Processors, due to T42 resolution
  - Lots of Cray CPP macros – artifact from CCM3 C90 days

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# Porting PCM to Cray X1

- Getting clean compile
  - Couldn't find suggested compiler option strings for typical ports in documentation
  - Convert "CRAY" CPP macro to "CRAY90"
  - Use __crayx1 CPP macro
  - Find X1 acceptable subset of I/O keywords
  - Convert system calls
  - Fortran versions of ceil2.c and pair.c

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# Porting PCM to Cray X1

- Attempt to execute PCM
  - Seg Fault
    - No output file
    - No traceback
  - Learn about call flush (101)
  - Insert lots of "I am here" print statements
  - Learn about ftn –D option

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# Porting PCM to Cray X1

- – -D option has fatal interactions with passed character variable lengths
  - SPR 727900

- Temporary Workaround

  Split dependency lists into char and non-char handling lists for each model

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# Porting PCM to Cray X1

- Finally 1 uninitialized variable found
- Finally 1 call statement with mis-matched array dimension and array name arguments found

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# Porting PCM to Cray X1

- PCM has multiple namelists in a single physical file
  - Depends on closing and reopening of file to not change location of file pointer
    - Didn't work on X1
  - Workaround
    - Separate namelists into individual files

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# Porting PCM to Cray X1

- Attempt to replace local lenchr function with len_trim intrinsic
- Test case on next slide

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```fortran
program stest100

implicit none

integer lenchr, l1, l2, l3

character*18 dummy

character*22 a

character*20 b

character*18 c

lenchr(dummy) = len_trim(dummy)

a = '12345678901234567890'

b = '12345678901234567890'

c = '123456789012345678'

l1 = lenchr(a)

l2 = lenchr(b)

l3 = lenchr(c)

end
```

# Porting PCM to Cray X1

- Cray X1 results:
- 40 phoenix:/dfs/home/wayland/test>a.out

  <span style="color:red">3*18</span>

  Not quite what I expected, but….

  IBM gives same result

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# Porting PCM to Cray X1

- Second try:
- Change length of ASF dummy argument
- Test case on next slide

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```fortran
program stest101

implicit none

integer lenchr, l1, l2, l3

character*20 dummy

character*22 a

character*20 b

character*18 c

lenchr(dummy) = len_trim(dummy)

a = '12345678901234567890'

b = '12345678901234567890'

c = '123456789012345678'

l1 = lenchr(a)

l2 = lenchr(b)

l3 = lenchr(c)

end
```

# Porting PCM to Cray X1

- Results in the following compile time diagnostic:

  43 phoenix:/dfs/home/wayland/test> ftn stest101.F

           l3 = lenchr(c)
                     ^

  ftn-848 ftn: ERROR STEST100, File = stest101.F, Line = 14, Column = 21

  Dummy argument "DUMMY" is longer than the actual argument.

- Not quite what I expected

- IBM gives:  20, 20, 18   What I expected

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# Porting PCM to Cray X1

- coreinfo dump analysis utility not much help

- Totalview hard to set up, hard to get X-Window tunnel view through to remote display

- TV did find location of next bug:

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# Porting PCM to Cray X1

- In ccm subroutine infil.F, loop with many exp expressions mis-compiled, resulting in runtime errors.

- Solution:  Convert expression arguments into temporary variables, insert if tests for out of range value and print statements.

- if ( c04 .gt. 709. ) print *,'infil: k,c04',k,',',c04

- Note: Print statement required!

- Will submit PSR for simplified case someday.

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```fortran
do k = 1, npt
    qsurf = qmelt(k) + qsdew(k)
    v = bch(k)*smpsat(k) / (0.5*dzsoi(1,k)*1000.)
    s = h2osoi(1,k)/watsat(k)
    c1 = qsurf - hksat(k)*(1.-v)
    c2 = hksat(k)*v
    sq = max( min(c1/c2, 1.), 0. )
    c3 = max( qrain(k), 1.e-20 )
    c4 = exp(-1./s)
    c5 = exp(-sq/s)
    c6 = exp( min(80., c1/c3) )          !upper limit prevents overflow
    c7 = exp( min(80.,-sq/s-sq*c2/c3) ) !upper limit prevents overflow
    if (qsurf .le. hksat(k)) then
       flx1 = qrain(k)*c4*exp( (qsurf-hksat(k))/c3 )
    else
       flx1 = (qrain(k)+qsurf-hksat(k)) * c4
    end if
    flx2 = (qrain(k)+c1)*(c5-c4) + c2*(c4*(1.+s)-c5*(sq+s))
    flx3 = qrain(k)**2 / (qrain(k)+c2*s) * c6 * (1.-c7)
    if (ist(k). eq. 1) then              !soil
       qover(k) = flx1+flx2+flx3
    else                                 !glaciers, lakes, wetlands
       qover(k) = 0.
    end if
    qinfl(k) = qrain(k) + qsurf - qover(k)
end do
```

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# Porting PCM to Cray X1

- Junk produced by pat_hwpc
  - ioctl PIOCWSTOP failed [No such file or directory]
  - ioctl PIOCSETPERFCONTROL failed [No such file or directory]

  - [1]   Exit 1   pat_hwpc -f mpirun -n 4 -t 700 pcm.B00.x1.4 < /dev/null
- Junk produced by pat_report SPR 726582
  - pat_report –i pcm.B00.x1.4_inst pcm.B00.x1.4_inst+134061pdt.xf > pcm.4.prof
  - [/opt/open/open/bin/pwd: C\2034\2031\2032^A^O\2033Rh^N: not found
  - /opt/open/open/bin/pwd: syntax error at line 1: `)' unexpected
  - ...................
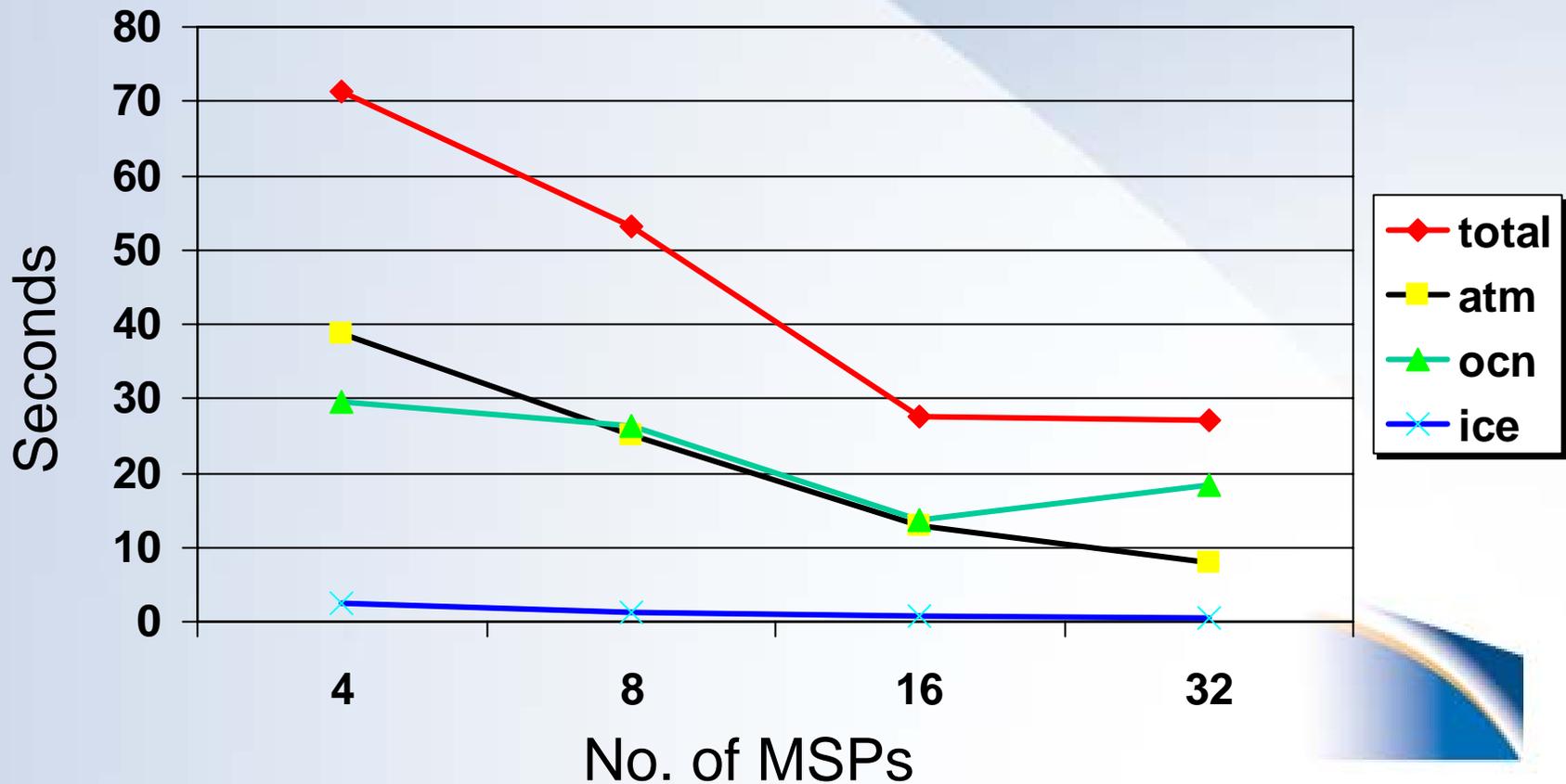- Fixed in PE 5.2

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# CURRENT PERFORMANCE

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# Time per simulated day



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# Performance Profile

```
  6.3% |    56.3% |   99610 |pe.1
---------------------------------------
  0.7% |    50.7% |   11202 |ninept_
  0.7% |    51.4% |   10773 |fivept_
  0.6% |    52.0% |   10302 |fcd_a2o_
  0.3% |    52.3% |    4464 |global_real_sum_
  0.2% |    52.6% |    3666 |MPI_CRAY_send_wait
  0.2% |    52.8% |    3253 |grcalc_
  0.2% |    52.9% |    2667 |__bcopy_wordstrm
  0.2% |    53.1% |    2586 |__bcopy_strm
  0.1% |    53.2% |    2181 |state_
  0.1% |    53.4% |    2101 |sw_4pt_
  0.1% |    53.5% |    2065 |__bcopy_prv
  0.1% |    53.6% |    1931 |fcd_o2a_
  0.1% |    53.7% |    1775 |grad_4pt_
  0.1% |    53.8% |    1723 |MPI_CRAY_recv_wait
```

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# Performance cont'd.

- 9 Point Operator

  X      X      X
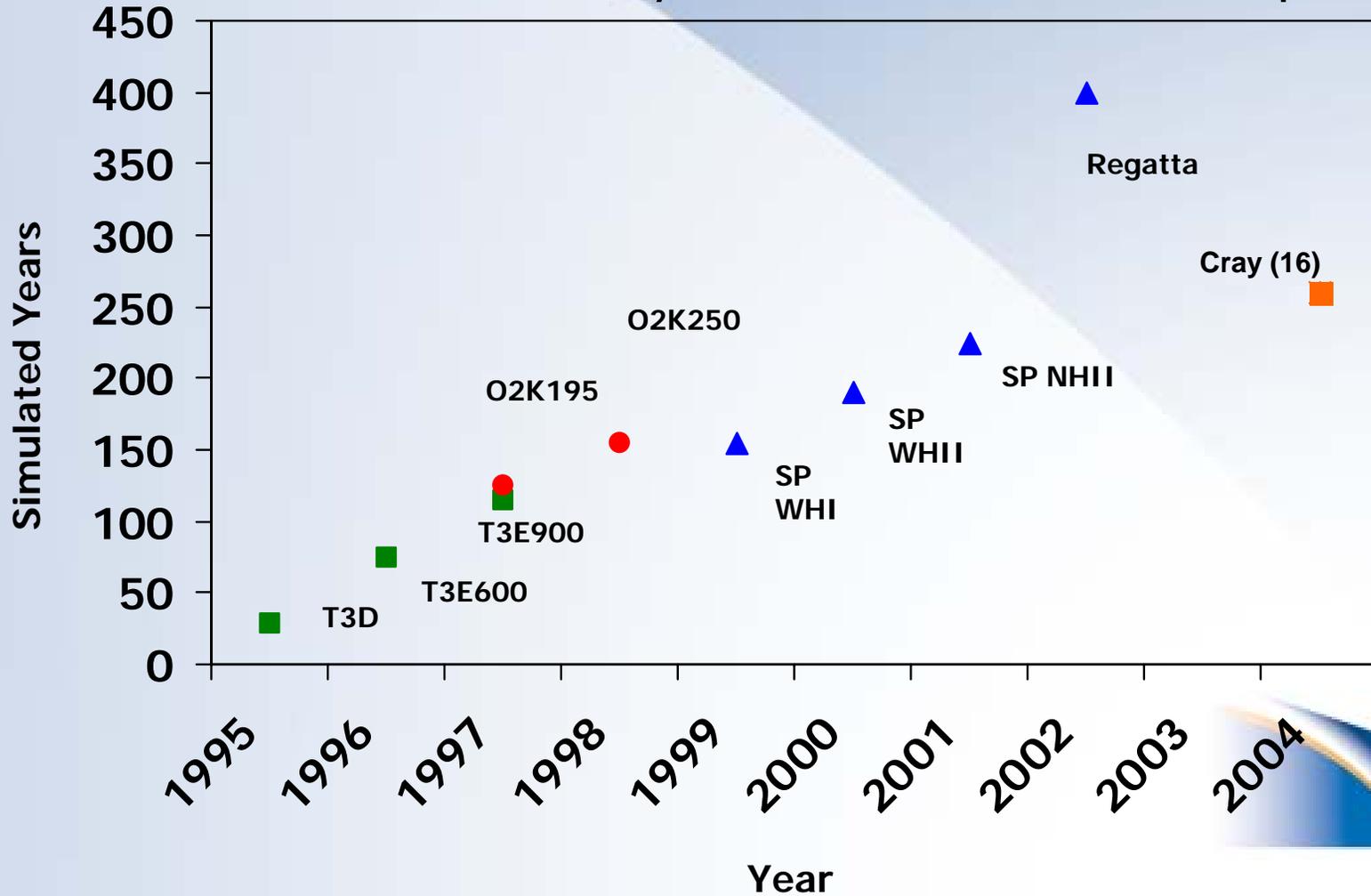
  X      O      X

  X      X      X

  5 Point Operator

  X      X      X

  X      O      X

  X      X      X

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# PCM Version 1

## *Simulated Years per Wallclock Month* 64pes



Chart showing Simulated Years (y-axis, 0 to 450) vs Year (x-axis, 1995 to 2004):

- T3D (green square) ~1995, ~28
- T3E600 (green square) ~1996, ~75
- T3E900 (green square) ~1997, ~112
- O2K195 (red circle) ~1997, ~127
- O2K250 (red circle) ~1998, ~155
- SP WHI (blue triangle) ~1999, ~153
- SP WHII (blue triangle) ~2000, ~188
- SP NHII (blue triangle) ~2001, ~223
- Regatta (blue triangle) ~2002, ~398
- Cray (16) (orange square) ~2004, ~258

**Year**

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# The End

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