PERFORMANCE ANALYSIS of REGIONAL Eta MODEL installation, running and optimization on different hardware/software platform

Marijana Crepulja
maja@meteo.yu

Aleksandar Miljković
aleksandar.miljkovic@coming.co.yu

11th Workshop on the use of High Performance Computing in Meteorology
Republic Hydrometeorological Service of Serbia

Outline

- NWP in Serbia - The Eta model characteristics
- Historical overview and description of present operational system
- Latest efforts in installation and running the Eta model on different platforms
- Conclusion
Development of NWP in Serbia

- In 1972 Belgrade University professors Zaviša Janjić and Fedor Mesinger developed the first version of regional NWP model in cooperation with the Federal Hydrometeorological Institute of Yugoslavia (HIBU).
- NWP model has been used operationally in Belgrade since 1979.
- After its unique vertical coordinate was defined by prof. Mesinger in 1984, the model was named the Eta model.
- Several model components were developed in National Center for Environmental Prediction (NCEP), Washington and Geophysical Fluid Dynamics Laboratory (GFDL), Princeton.
The Eta model characteristics

- Limited area grid point model based on finite differences numerical methods
- The horizontal grid is Arakawa semi-staggered E grid defined in a transformed lat/lon coordinate system
- \( h \) points carry surface pressure, cloud water temperature, specific humidity, vertical velocity, turbulent kinetic energy and passive substances
- \( v \) points carry \( u \) and \( v \) components of the horizontal wind
Eta coordinate

\[ \eta = \left( \frac{p - p_T}{p_s - p_T} \right) \eta_s \]

where:
- \( p \) is the pressure at the surface
- \( p_T \) is the pressure at the top of the atmosphere
- \( p_s \) is the pressure at the model surface
- \( \eta_s \) is the eta coordinate at the model surface

Reference of standard atmospheric pressure at model surface \( Z_s \)
Height of model surface
\( \eta \) = Eta surface

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## Computer resources

<table>
<thead>
<tr>
<th>Computers / year</th>
<th>NWP Eta model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro VAX / 1988</td>
<td>Resolution 1.1°; 36 hour forecast; 16 vert.levels; time step 120s, 759 numerical points</td>
</tr>
<tr>
<td>CONVEX -two processors / 1991</td>
<td>Resolution 0.4°; 48 hour forecast; 16 vert.levels; time step 120s, 6385 numerical points</td>
</tr>
<tr>
<td>Sgi Indigo2 / 1995</td>
<td>Resolution 52 km; 48 hour forecast; 32 vert.levels; time step 120s, 8773 numerical points</td>
</tr>
<tr>
<td>Pentium III CPU 600MHz / 1998</td>
<td>Resolution 52 km; 48 hour forecast; 32 vert.levels; time step 120s; (AVN LBC), 8773 numerical points</td>
</tr>
<tr>
<td>BEOWULF cluster 3X3 and 4X4 CPU 1.4MHz / 2001</td>
<td>Resolution 18km; 5 days forecast; 32 vert.levels; time step 45s; (DWD LBC), 70000 numerical points</td>
</tr>
</tbody>
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One hour forecast on different platforms


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Agenda

• Our Mission
• Hardware Platform
• OS Consideration
• Porting Adventure
• Achieved Results
• Yet to be done…

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Our Mission

• Our goal is to speed up Eta model as much as possible, considering price/performance ratio

• 32bit platform is already exploited to maximum (PGA Compiler, SMP, Clustering)
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Hardware Platform

- Itanium 2 is Our Platform of Choice
  - EPIC (Itanium) goes beyond simple GHz
  - Excellent Scalability
    - From 2 to 128 CPUs per box
    - Up to 84 CPUs per rack
  - Support all relevant OS platforms and more
    - SuSE and RedHat Linux
    - Windows
    - HP-UX
    - OpenVMS
  - Promising Platform
    - Dual Core 9M Itanium 2 Already available
    - Dual Core 12M Itanium 2 in 2005

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OS Consideration

- **HP-UX For Performance**
  - HP Fortran Compiler
  - Mature Software Platform

- **Linux For Price & Performance**
  - Intel Linux Fortran Compiler
  - Proven Development Platform
  - User Friendly Environment
  - Portable Code
Porting Adventure (1 of 3)

• Starting environment
  – Linux IA32
  – PGA Compiler

• Two destination environments
  – HP-UX
  – Linux 64bit Itanium2
Porting Adventure (2 of 3)

- HP Fortran Compiler follows f90 standards (Easy to port)
- GRIB library requires minor modification since it supports HP-UX PA, but not HP-UX Itanium2
- Auto-parallelization and Itanium2 optimization led to significant performance boost
  - Without Itanium2 optimization - 19min per iteration (1h)
  - With Itanium2 optimization – 3min per iteration! (1h)
Porting Adventure (3 of 3)

- Intel Fortran Compiler – Faster but less compatible
- Code modification required for GRIB library and Eta model
- Different optimization options must be provided for different Eta model stages while compiling the model
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Achieved Results

• We are at the beginning of porting journey
• Reference platform
  – Two-way rx2600 Itanium2 3M 900MHz
  – RedHat Linux AS
  – 4GB RAM
  – 5min per Iteration (1h of forecast)
Yet to be done…

• General directions
  – Optimize on single node
    • Modifying code and introducing Intel Fortran specific code
    • Introducing new Itanium2 processors
      – More cache leads to more FPU performance
      – Dual core leads to higher density
  – Optimize for Cluster (MPI)
    • MPI – Intel Linux Fortran Compiler Issues?
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