



pFlogger: The Parallel Fortran Logging Utility

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POSITION

Use of text-base messages in HPC applications is typically undisciplined, leading to a chaotic hodgepodge that is of limited value to developers and users. Logging frameworks can bring order to the chaos and significantly improve our ability to extract useful information.

Typical problems:

- ❖ Important messages obscured by fountain of routine messages
- ❖ Performance
 - ❖ User adds a print statement in an inner loop or across all processes
- ❖ Anonymity – important message of unknown origin
 - ❖ Which process
 - ❖ Which software component
- ❖ Loss of productivity
 - ❖ Recompile to activate low-level debug diagnostics

If only we could ...

- ❖ Route warnings and errors to prominent location
 - ❖ And profiler data and ...
- ❖ Suppress low severity ("debugging") messages
- ❖ Suppress duplicate messages on sibling processes
- ❖ Annotate messages with:
 - ❖ Time stamp
 - ❖ Process rank
 - ❖ Software component
 - ❖ Other application-specific metadata
 - ❖ ...

And ... do all of this dynamically at run time (without recompilation)

The Python Logging Framework

The main classes:

- ❖ **LogRecord** – encapsulates a message and its context
 - ❖ Severity is determined statically (in source code)
- ❖ **Handler** – represents different *audiences* for messages
 - ❖ Generalization of a file: could be console, email, SMS, ...
 - ❖ Has a run-time severity level threshold
- ❖ **Logger** – represents different *creators* of messages
 - ❖ Typically one per software component/library
 - ❖ Each has a run-time severity threshold
 - ❖ Has a list of associated Handler objects
 - ❖ Also routes messages through ancestor Loggers' handlers.

Other important classes:

- ❖ **LoggerManager** – container of Logger objects
- ❖ **Formatter** – used by Handler objects to annotate messages (uses dictionary)
- ❖ **Filter** – Selectively suppress messages in Loggers and Handlers

Severity Levels

10 DEBUG

20 INFO

30 WARNING

40 ERROR

50 CRITICAL

0 NOTSET*

Fortran Translation of Python Logger

Wanted something like this for a long time ...

Enabled by two technologies:

- ❖ Arrival of robust object-oriented capabilities in Fortran compilers
 - ❖ But still have several compiler-specific workarounds ...
- ❖ Internally developed FTL (poor-man analog of C++ STL)
 - ❖ Substantially reduces effort to define/use vectors and dictionaries from Fortran
 - ❖ In process of being released as open source (more on this later)

Alternative approach: Provide Fortran wrappers to Python logger.

Configuring Logger (via YAML)

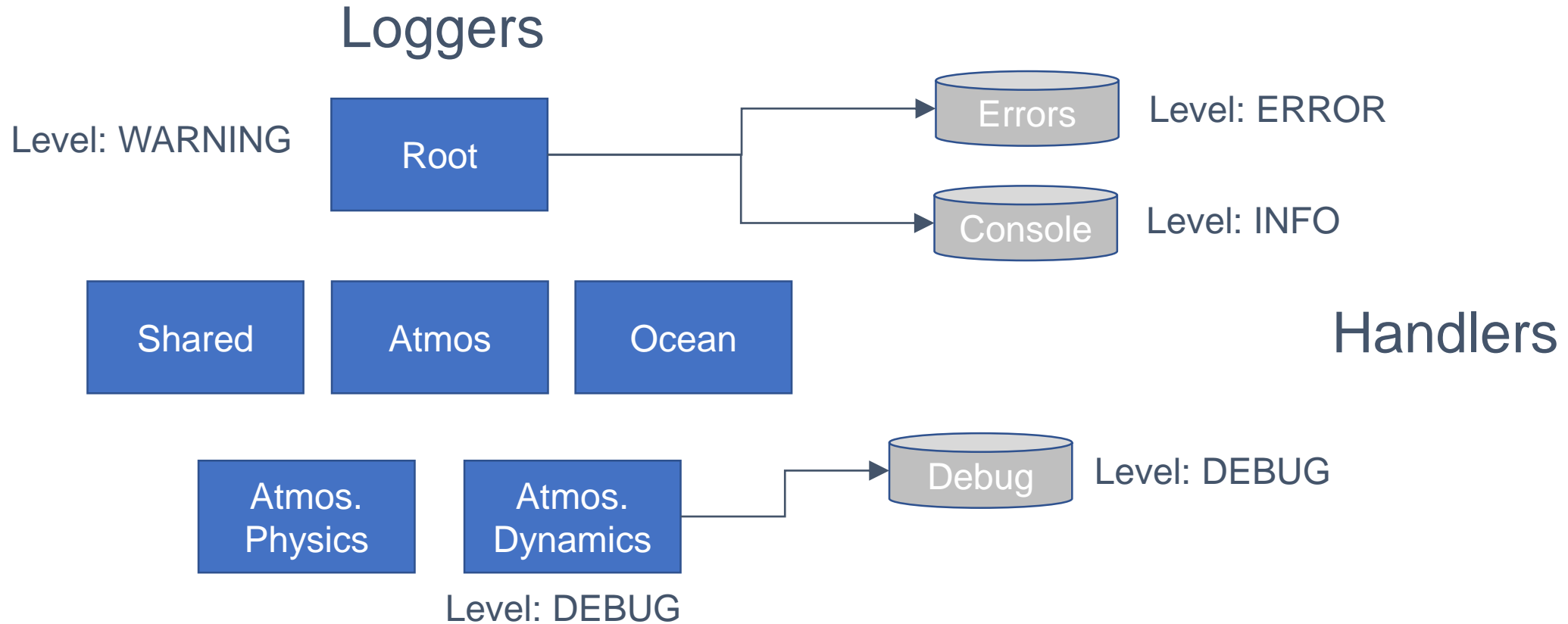
```
formatters:
  basic:
    class: Formatter
    format: '%(name) a~: %(levelname) a~: %(message) a'
  column:
    class: Formatter
    format: '(%(i)i3.3,%(j)i3.3): %(levelname)'

handlers:
  console:
    class: streamhandler
    formatter: basic
    unit: OUTPUT_UNIT
    level: WARNING
  warnings:
    class: FileHandler
    filename: warnings.log
    level: WARNING
    formatter: basic
```

```
...
root:
  handlers: [console,warnings]

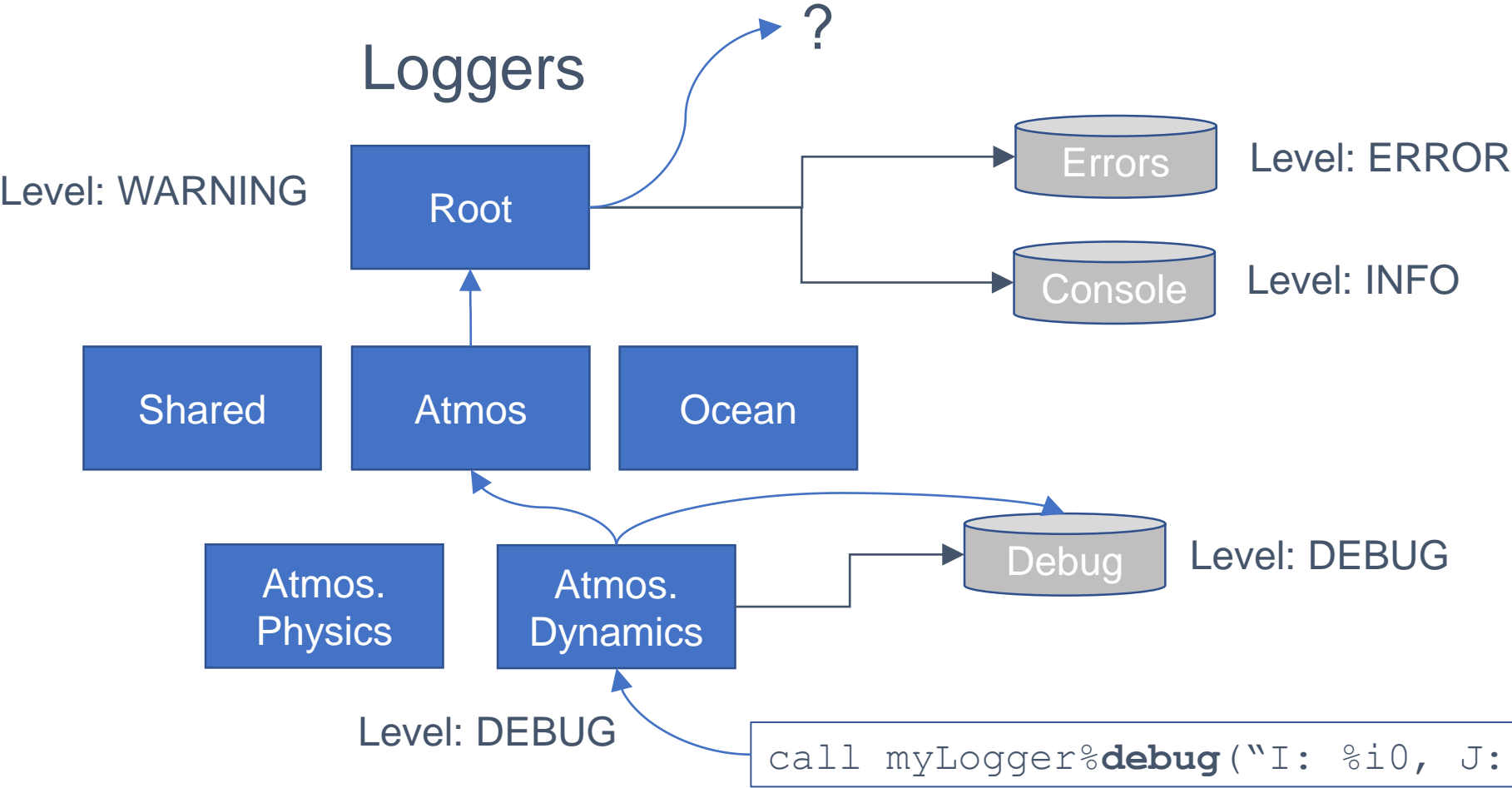
loggers:
  main:
    level: INFO
  main.A:
    level: WARNING
  main.B:
    level: INFO
```

Life of a Message

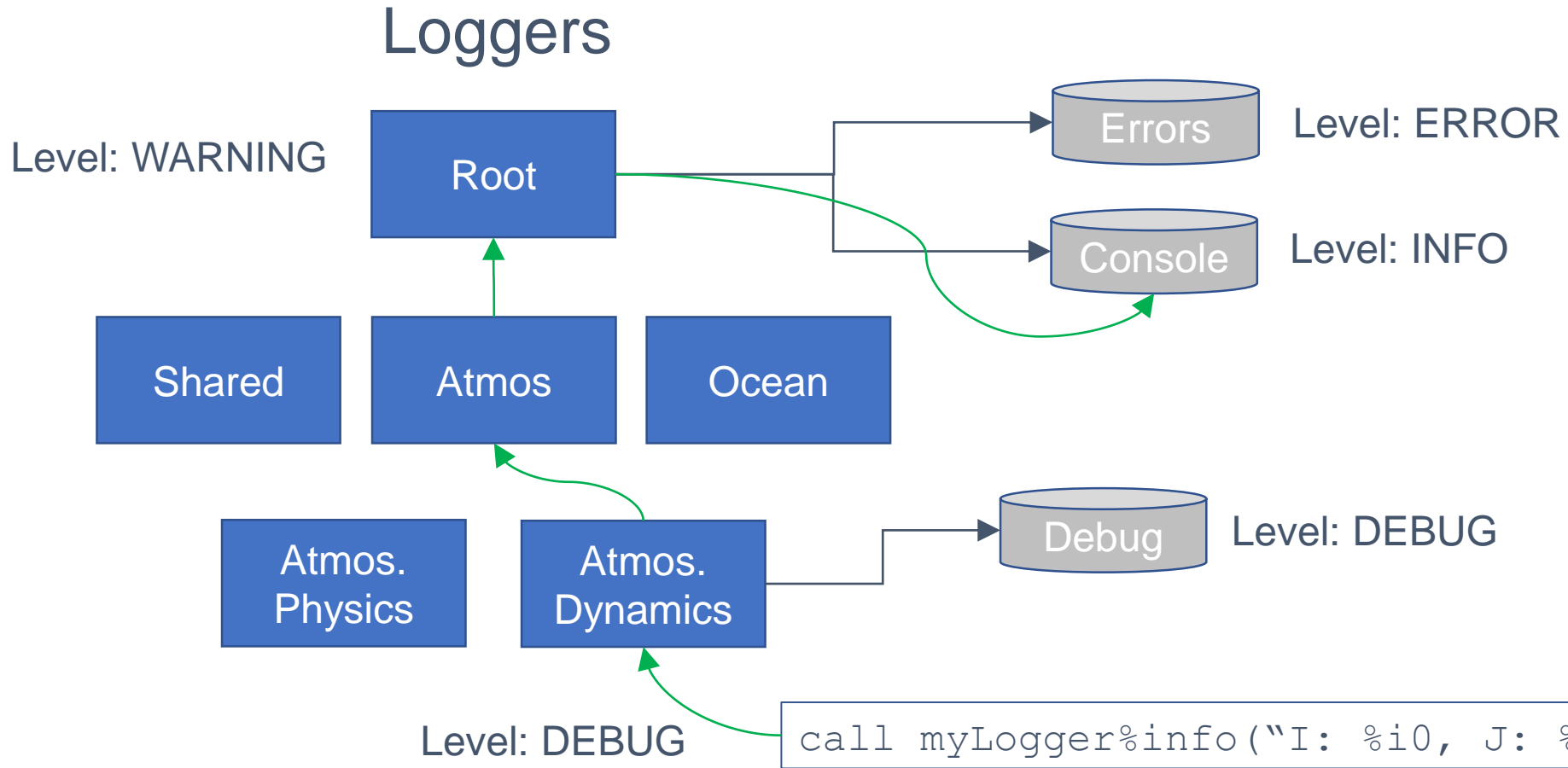




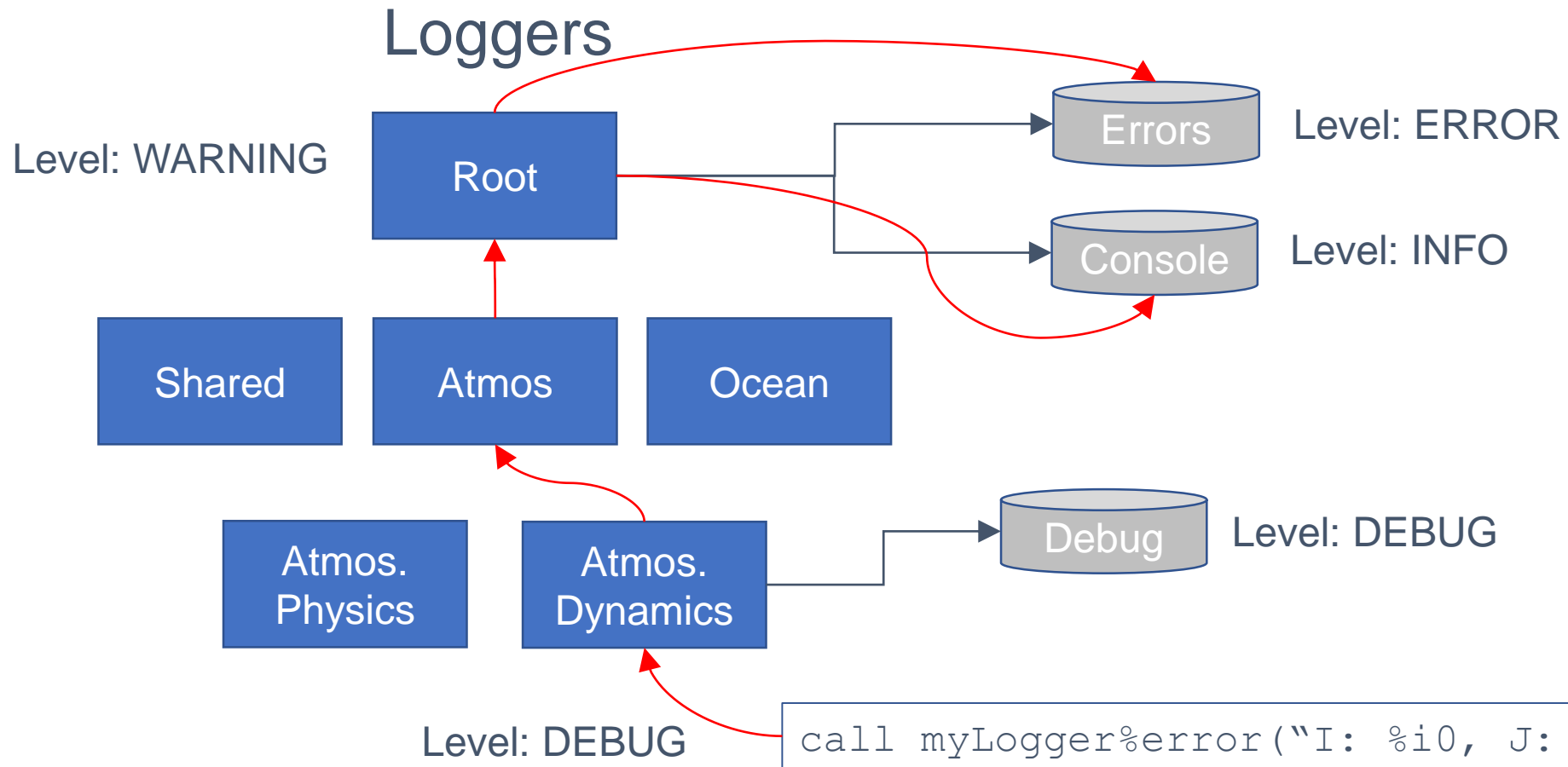
Life of a Message



Life of a Message



Life of a Message



Extensions for MPI Use

- ❖ LoggerManager – configured with global comm (defaults to MPI_COMM_WORLD)
- ❖ Logger – can be associated with a communicator (defaults to global)
 - root_level: independent threshold for root process
- ❖ Handler
 - Lock – used to allow multiple processes to share access to a file
 - MpiLock – uses one-sided MPI communication
 - FileSystemLock – limited portability, but allows multi-executable sharing
 - MpiFilter – used to restrict which processes' messages are reported
 - MpiFileHandler subclass
 - Messages from each process are routed to separate file
- ❖ MpiFormatter subclass: knows about rank and #PE's for annotations

Advanced Capabilities

I.e., Things that are harder to use

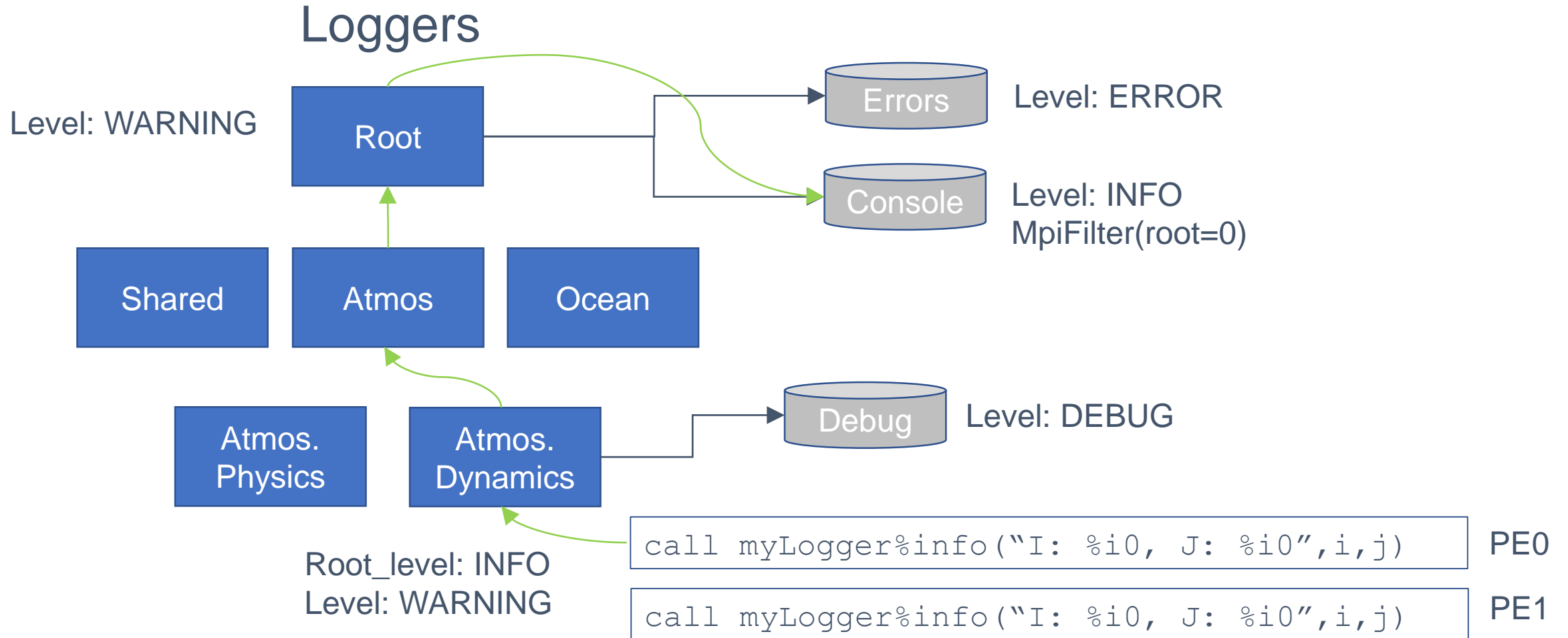
Subcommunicators: How to specify in run-time configuration file?

1. Construct communicators prior to initializing framework
2. Build dictionary of named communicators
3. Pass as optional argument to framework configuration step

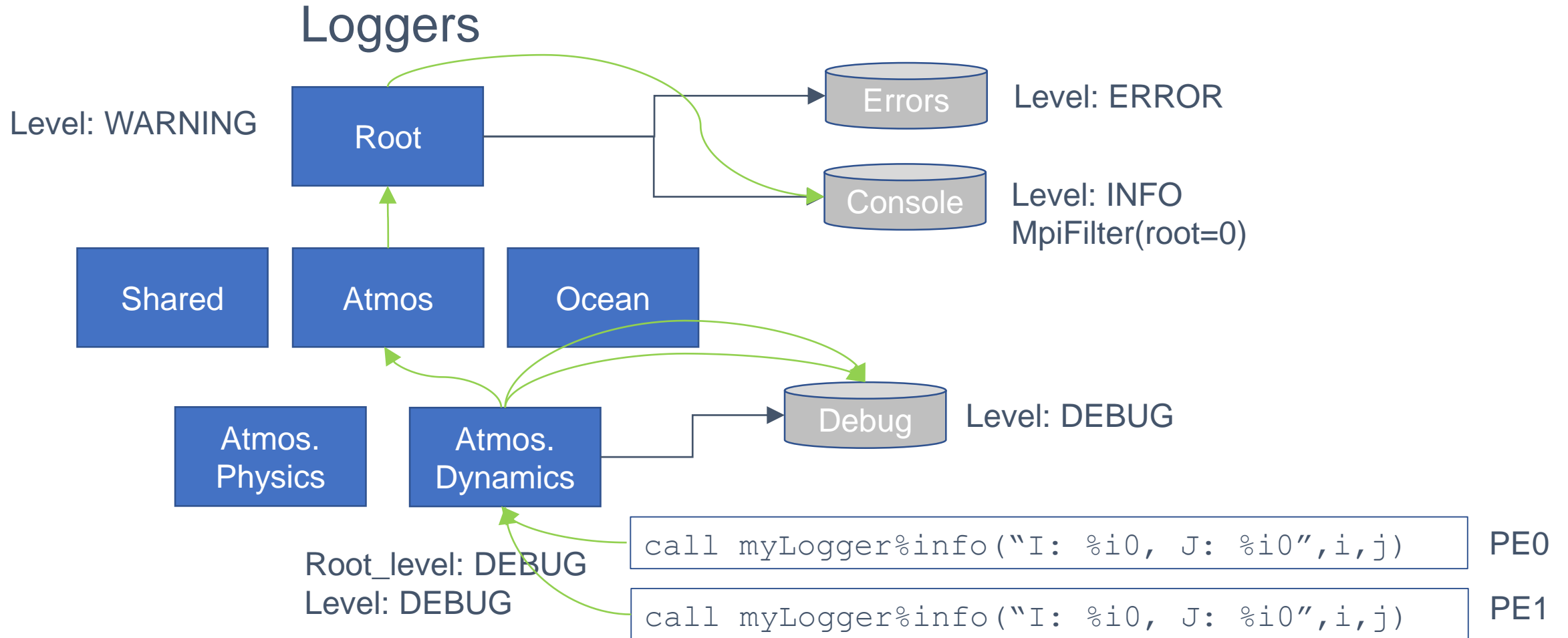
Simulation time: Enable annotation of messages with model's internal representation of time/phase information

1. Create a custom procedure that accesses model internal state and returns a dictionary of time-related fields. E.g. {'year':2000, 'month':'May', 'phase':'quality control'}
2. Set logger global procedure pointer "get_sim_time()" to custom procedure.

Life of a Message: MPI



Life of a Message: MPI



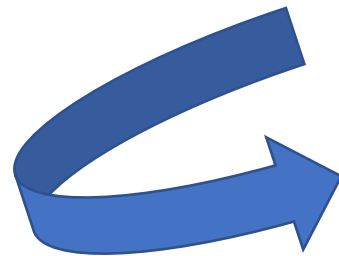
Instrumenting with pFlogger

Easy and straightforward:

- ❖ Initialization – near beginning of application
- ❖ Declare logger in each component
- ❖ Replace print/write statements

```
if (am_i_root()) write(*,*)
```

```
use pFlogger
...
call initialize(MPI_COMM_WORLD)
...
call logging%load_file('my_config.yaml')
class Logger, pointer :: myLogger
...
myLogger => logging%get_logger('full.name')
```



```
call my_Logger%info('mass: %*',m)
```

Benchmarks

Synthetic use case performance ratios

Use Case	Intel-17	GCC 7.1	NAG 6.1
Simple text message	5.5x	10x	15x
Message with scalar items	8x	16x	5x
Suppressed message	0.004x	0.03x	0.15x
Split parallel log message	1.1x	7x	-
Shared parallel log message	5x	8x	-

Build times of GEOS GCM (Large Earth system model)

Compiler	Optimization	T baseline	T pflogger
Intel-17	O0	218.6	250.3
Intel-17	O3	735	797.
Gfortran-7	O0	178.3	198.3

Open Source?

In progress, but the gears at NASA turn slowly ...

- ❖ Can arrange for project license for groups that have NASA or other US gov't affiliation.
- ❖ Will otherwise collect email addresses from interested parties for when open source is achieved.
- ❖ If interested, send me email Tom.Clune@nasa.gov

Summary

- ❖ pFlogger appears ready for beta testing in HPC applications
 - ❖ Further optimizations needed for intensive use cases
 - ❖ Some tweaks to initialization interfaces are expected
- ❖ Plan to integrate pFlogger into dev branch of GEOS in the near future
 - ❖ Full instrumentation will proceed on a longer time scale

- ❖ Largest problem – too much flexibility!



Thanks to ...

NASA's Modeling and Prediction Program for funding this work.



References

V. Sajip, “logging -- logging facility for Python”,
<https://docs.python.org/2/library/logging.html>

In defense of the PRINT statement ...

PRINT is very versatile:

- ❖ Arbitrary number *and* type of items
- ❖ Convenient default (*) formatting
- ❖ Flexible edit descriptors that allow for precision formatting

But ... most of this versatility is frozen at compile time.

OTOH, very difficult to emulate the versatility in a procedure interface.