Introduction to Logging

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Note: This is an supplemental subject component to Dave's Python training classes. Details at:

http://www.dabeaz.com/python.html

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Application Logging

- Complex systems are often instrumented with some kind of logging capability
    - Debugging and diagnostics
    - Auditing
    - Security
    - Performance statistics
- Example : Web server logs

Error Handling

- Even in small programs, you often run into subtle issues related to exception handling

```
for line in open("portfolio.dat"):
    fields = line.split()
    try:
        name = fields[0]
        shares = int(fields[1])
        price  = float(fields[2])
    except ValueError:
        ????
```

Do you print a warning?

```
print "Bad line", line
```

Do you ignore the error?

```
pass
```

- Short answer: It depends

The Logging Problem

- Logging is a problem that seems simple, but usually isn't in practice.
- Problems:
  - Figuring out what to log
  - Where to send log data
  - Log data management
  - Implementation details

Homegrown Solutions

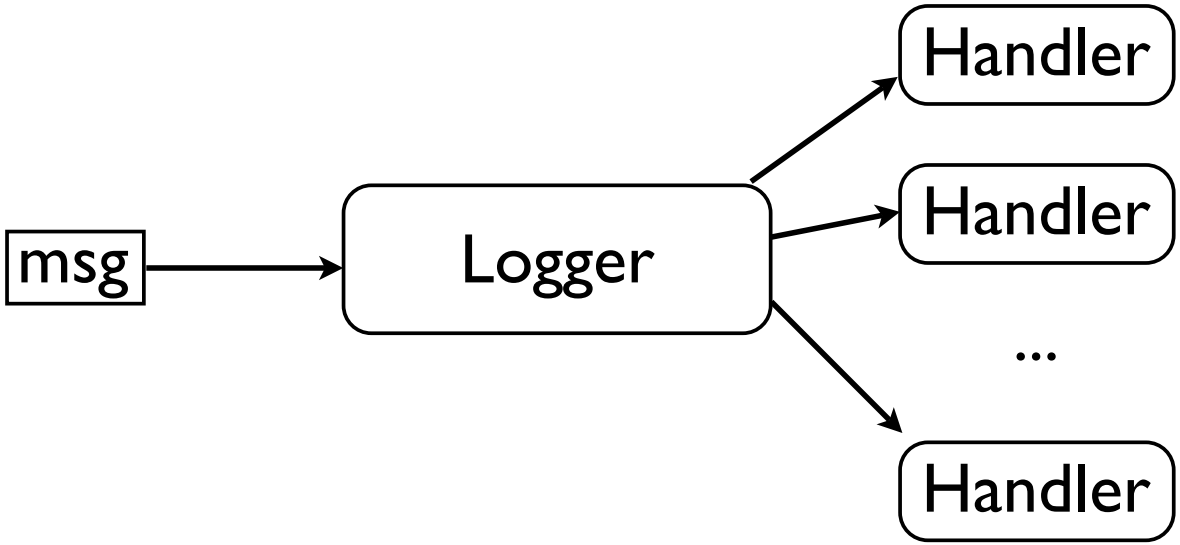
- Observation: Most significant applications will implement some kind of logging facility.
- Homegrown solutions tend to grow into a huge tangled hack.
- No one actually wants to work on logging---it's often added as a half-baked afterthought.

logging Module

- A module for adding a logging capability to your application.
- A Python port of log4j (Java/Apache)
- Highly configurable
- Implements almost everything that you could possibly want for a logging framework

Logger Objects

- logging module relies on "Logger" objects
- A Logger is a target for logging messages
- Routes log data to one or more "handlers"



Logging Big Picture

- Creating Logger objects
- Sending messages to a Logger object
- Attaching handlers to a Logger
- Configuring Logger objects

Getting a Logger

- To create/fetch a Logger object

```
log = logging.getLogger("logname")
```

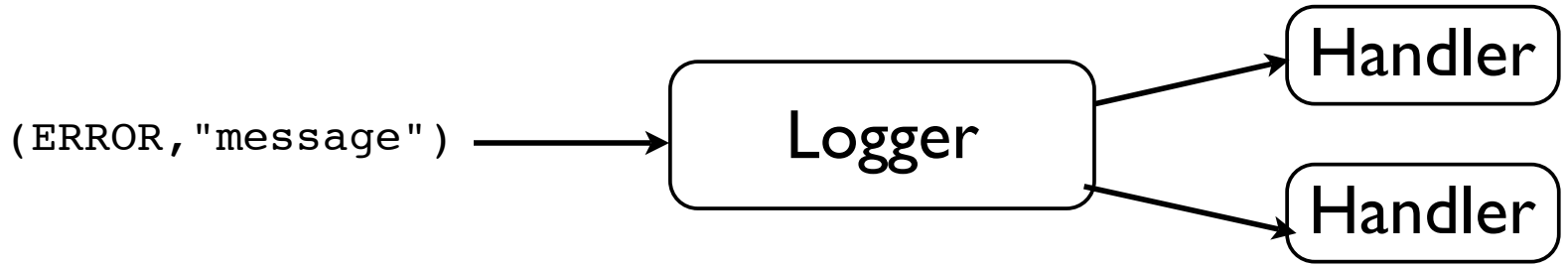
- If this is the first call, a new Logger object is created and associated with the given name
- If a Logger object with the given name was already created, a reference to that object is returned.
- This is used to avoid having to pass Logger objects around between program modules.

Logging Messages

- The logging module defines 5 logging "levels"

```
CRITICAL      50          Critical errors
ERROR         40          Error messages
WARNING       30          Warning messages
INFO          20          Information messages
DEBUG         10          Debugging messages
```

- A logging message consists of a logging level and a logging message string



How to Issue a Message

- Methods for writing to the log

```
log.critical(fmt [, *args ])
log.error(fmt [, *args ])
log.warning(fmt [, *args ])
log.info(fmt [, *args ])
log.debug(fmt [, *args ])
```

- These are always used on some Logger object

```
import logging
log = logging.getLogger("logname")

log.info("Hello World")
log.critical("A critical error occurred")
```

Logging Messages

- Logging functions work like printf

```
log.error("Filename '%s' is invalid", filename)
log.error("errno=%d, %s", e.errno,e.strerror)
log.warning("'%s' doesn't exist. Creating it", filename)
```

- Here is sample output

```
Filename 'foo.txt' is invalid
errno=9, Bad file descriptor
'out.dat' doesn't exit. Creating it
```

Logging Exceptions

- Messages can optionally include exception info

```
try:
  ...
except RuntimeError:
  log.error("Update failed",exc_info=True)
```

- Will include traceback info from the current exception (if any)
- Sample output with exception traceback

```
Update failed
Traceback (most recent call last):
  File "<stdin>", line 2, in <module>
RuntimeError: Invalid user name
```

Example Usage

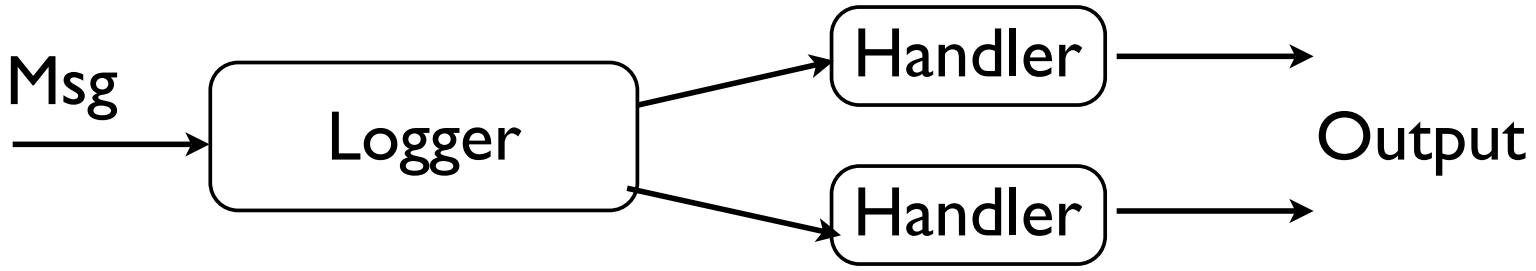
- Logging often gets added as an optional feature

```
def read_portfolio(filename,log=None):
    for line in open(filename):
        fields = line.split()
        try:
            name = fields[0]
            shares = int(fields[1])
            price  = float(fields[2])
        except ValueError:
            if log:
               log.warning("Bad line: %s",line)
```

- By doing this, the handling of the log message becomes user-configurable
- More flexible than just hard-coding a print

Log Handlers

- A Logger object only receives messages
- It does not produce any output
- Must use a handler to output messages



Attaching a Handler

- Example of attaching a handler to a Logger

```
import logging, sys

# Create a logger object
log = logging.getLogger("logname")

# Create a handler object
stderr_hand = logging.StreamHandler(sys.stderr)

# Attach handler to logger
log.addHandler(stderr_hand)

# Issue a log message (routed to sys.stderr)
log.error("An error message")
```

Attaching Multiple Handlers

- Sending messages to stderr and a file

```
import logging, sys

# Create a logger object
log = logging.getLogger("logname")

# Create handler objects
stderr_hand  = logging.StreamHandler(sys.stderr)
logfile_hand = logging.FileHandler("log.txt")

# Attach the handlers to logger
log.addHandler(stderr_hand)
log.addHandler(logfile_hand)

# Issue a log message.  Message goes to both handlers
log.error("An error message")
```

Handler Types

- There are many types of handlers

```
logging.StreamHandler
logging.FileHandler
logging.handlers.RotatingFileHandler
logging.handlers.TimedRotatingFileHandler
logging.handlers.SocketHandler
logging.handlers.DatagramHandler
logging.handlers.SMTPHandler
logging.handlers.SysLogHandler
logging.handlers.NTEventLogHandler
logging.handlers.MemoryHandler
logging.handlers.HTTPHandler
```

- Consult a reference for details.
- More examples later

Level Filtering

- All messages have numerical "level"

```
50   CRITICAL
40   ERROR
30   WARNING
20   INFO
10   DEBUG
0    NOTSET
```

- Each Logger has a level filter

```
log.setLevel(logging.INFO)
```

- Only messages with a level higher than the set level will be forwarded to the handlers

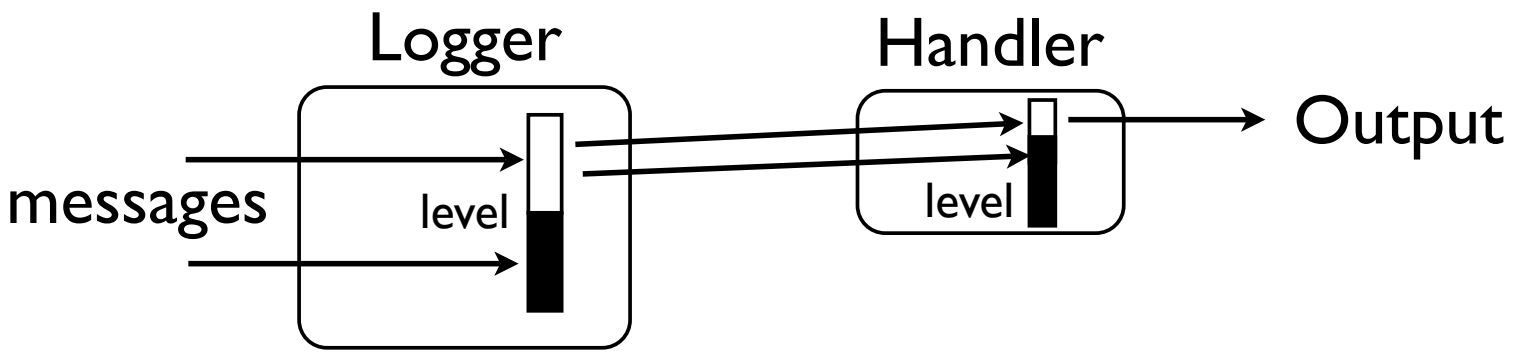
Level Filtering

- All Handlers also have a level setting

```
stderr_hand = logging.StreamHander(sys.stderr)
stderr_hand.setLevel(logging.INFO)
```

- Handlers only produce output for messages with a level higher than their set level
- Each Handler can have its own level setting

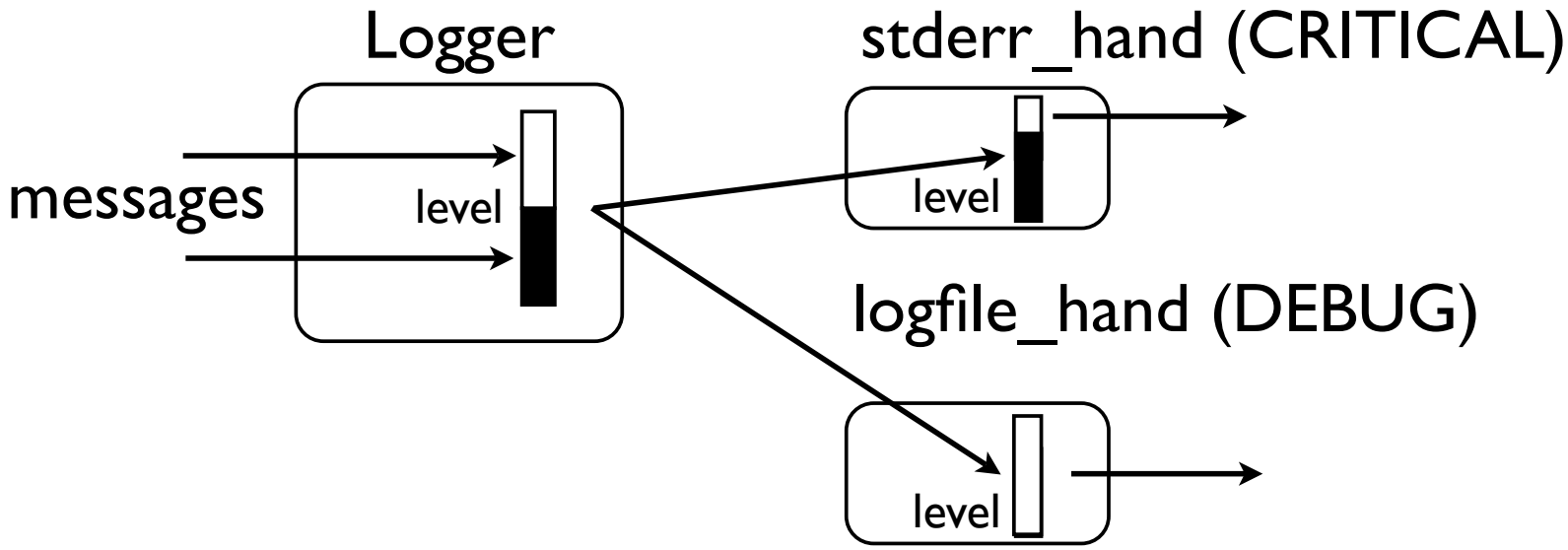
Level Filtering



- Big picture : Different objects are receiving the messages and only responding to those messages that meet a certain level threshold
- Logger level is a "global" setting
- Handler level is just for that handler.

Level Filtering Example

```
# Create handler objects
stderr_hand  = logging.StreamHandler(sys.stderr)
stderr_hand.setLevel(logging.CRITICAL)
logfile_hand = logging.FileHandler("log.txt")
logfile_hand.setLevel(logging.DEBUG)
```



Advanced Filtering

- All log messages can be routed through a filter object.

```
# Define a filter object. Must implement .filter()
class MyFilter(logging.Filter):
    def filter(self,logrecord):
        # Return True/False to keep message
        ...

# Create a filter object
myfilt = MyFilter()

# Attach it to a Logger object
log.addFilter(myfilt)

# Attach it to a Handler object
hand.addFilter(myfilt)
```

Advanced Filtering

- Filter objects receive a LogRecord object

```
class MyFilter(logging.Filter):
    def filter(self,logrecord):
        ...
```

- LogRecord attributes

logrecord.name	Name of the logger
logrecord.levelno	Numeric logging level
logrecord.levelname	Name of logging level
logrecord.pathname	Path of source file
logrecord.filename	Filename of source file
logrecord.module	Module name
logrecord.lineno	Line number
logrecord.created	Time when logging call executed
logrecord.asctime	ASCII-formated date/time
logrecord.thread	Thread-ID
logrecord.threadName	Thread name
logrecord.process	Process ID
logrecord.message	Logged message

Filtering Example

- Only produce messages from a specific module

```
class ModuleFilter(logging.Filter):
    def __init__(self,modname):
        logging.Filter.__init__(self)
        self.modname = modname
    def filter(self,logrecord):
        return logrecord.module == self.modname

log = getLogger("logname")
modfilt = ModuleFilter("somemod")
log.addFilter(modfilt)
```

Multiple Filters

- Multiple Filters may be added

```
log.addFilter(f)
log.addFilter(g)
log.addFilter(h)
```

- Messages must pass all to be output
- Filters can be removed later

```
log.removeFilter(f)
```

Log Message Format

- By default, log messages are just the message

```
log.error("An error occurred")
```

```
An error occurred
```

- However, you can add more information
  - Logger name and level
  - Thread names
  - Date/time

Customized Formatters

- Create a Formatter object

```
# Create a message format
msgform = logging.Formatter(
  "%(levelname)s:%(name)s:%(asctime)s:%(message)s"
)

# Create a handler
stderr_hand = logging.StreamHandler(sys.stderr)

# Set the handler's message format
stderr_hand.setFormatter(msgform)
```

- Formatter determines what gets put in output

```
ERROR:logname:2007-01-24 11:27:26,286:Message
```

Message Format

- Special format codes

`%(name)s`	Name of the logger
`%(levelno)s`	Numeric logging level
`%(levelname)s`	Name of logging level
`%(pathname)s`	Path of source file
`%(filename)s`	Filename of source file
`%(module)s`	Module name
`%(lineno)d`	Line number
`%(created)f`	Time when logging call executed
`%(asctime)s`	ASCII-formated date/time
`%(thread)d`	Thread-ID
`%(threadName)s`	Thread name
`%(process)d`	Process ID
`%(message)s`	Logged message

- Information is specific to where logging call was made (e.g., source file, line number, etc)

Message Formatting

- Each Handler has a single message formatter
- Use setFormatter() to set it

```
hand.setFormatter(form)
```

- Different handlers can have different message formats

Multiple loggers

- An application may have many loggers
- Each is identified by a logger name

```
netlog = logging.getLogger("network")
guilog = logging.getLogger("gui")
thrlog = logging.getLogger("threads")
```

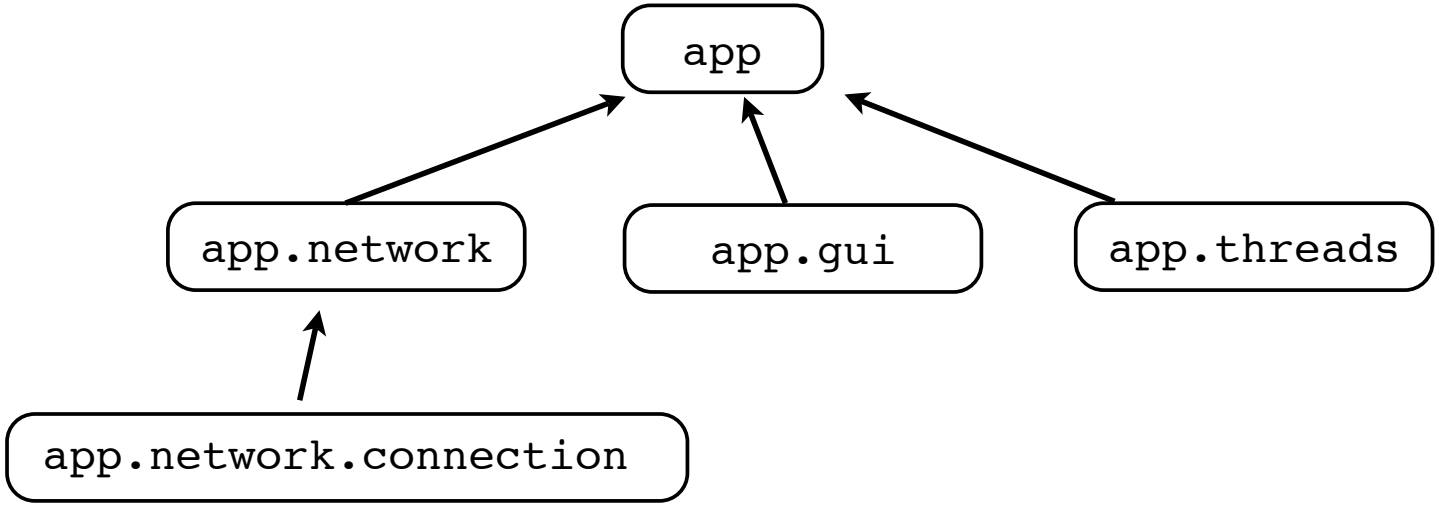
- Each logger object is independent
- Has own handlers, filters, levels, etc.

Hierarchical Loggers

- Loggers can be organized in a name hierarchy

```
applog = logging.getLogger("app")
netlog = logging.getLogger("app.network")
conlog = logging.getLogger("app.network.connection")
guilog = logging.getLogger("app.gui")
thrlog = logging.getLogger("app.threads")
```

- Messages flow up the name hierarchy



Hierarchical Loggers

- With a hierarchy, filters and handlers can be attached to every single Logger involved
- The level of a child logger is inherited from the parent unless set directly
- To prevent message forwarding on a Logger:

```
log.propagate = False
```

- Commentary: Clearly it can get quite advanced

The Root Logger

- Logging module optionally defines a "root" logger to which all logging messages are sent
- Initialized if you use one of the following:

```
logging.critical()
logging.error()
logging.warning()
logging.info()
logging.debug()
```

The Root Logger

- Root logger is useful for quick solutions and short scripts

```
import logging
logging.basicConfig(
    level    = logging.INFO,
    filename = "log.txt",
    format   = "%(levelname)s:%(asctime)s:%(message)s"
)

logging.info("My program is starting")
...
```

Putting it Together

- Adding logging to your program involves two steps
  - Adding support for logging objects and adding statements to issue log messages
  - Providing a means for configuring the logging environment
- Let's briefly talk about the second point

Logging Configuration

- Logging is something that frequently gets reconfigured (e.g., during debugging)
- To configure logging for your application, there are two approaches you can take
    - Isolate it to a well-known module
    - Use config files (ConfigParser)

A Sample Configuration

- A sample configuration module

```
# logconfig.py
import logging, sys

# Set the message format
format = logging.Formatter(
    "%(levelname)-10s %(asctime)s %(message)s")

# Create a CRITICAL message handler
crit_hand = logging.StreamHandler(sys.stderr)
crit_hand.setLevel(logging.CRITICAL)
crit_hand.setFormatter(format)

# Create a handler for routing to a file
applog_hand = logging.FileHandler('app.log')
applog_hand.setFormatter(format)

# Create a top-level logger called 'app'
app_log = logging.getLogger("app")
app_log.setLevel(logging.INFO)
app_log.addHandler(applog_hand)
app_log.addHandler(crit_hand)
```

A Sample Configuration

- To use the previous configuration, you import

```
# main.py
import logconfig
import otherlib
...
```

- Mainly, you just need to make sure the logging gets set up before other modules start using it
- In other modules...

```
import logging
log = logging.getLogger('app')
...
log.critical("An error occurred")
```

Using a Config File

- You can also configure with an INI file

```
; logconfig.ini

[loggers]
keys=root,app

[handlers]
keys=crit,applog

[formatters]
keys=format

[logger_root]
level=NOTSET
handlers=

[logger_app]
level=INFO
propagate=0
qualname=app
handlers=crit,applog
```

```
[handler_crit]
class=StreamHandler
level=CRITICAL
formatter=format
args=(sys.stderr,)

[handler_applog]
class=FileHandler
level=NOTSET
formatter=format
args=('app.log',)

[formatter_format]
format=%(levelname)-10s %(asctime)s %(message)s
datefmt=
```

Reading a Config File

- To use the previous configuration use this

```
# main.py
import logging.config
logging.config.fileConfig('logconfig.ini')
...
```

- The main advantage of using an INI file is that you don't have to go in and modify your code
- Easier to have a set of different configuration files for different degrees of logging
- For example, you could have a production configuration and a debugging configuration

Summary

- There are many more subtle configuration details concerning the logging module
- However, this is enough to give you a small taste of using it in order to get started