Thespian

Usage

Thespian
Python Actor System

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Thespian Project

TheDoc-02

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Contents

1 Actor Overview

1.1 Actors

At the core, an Actor system is very simple. An Actor is a standalone entity that receives messages from other Actors and does one of three things:

1. Changes internal state
2. Creates other Actors
3. Sends a finite number of messages to other Actors

Importantly, an Actor cannot access internals of other Actors, and it should not access any globals. Any information used by the Actor should be passed to the Actor via a message or else generated internally.

Actors may only communicate with other Actors by sending messages to those Actors, using known addresses for those target Actors.

Note that messages are unidirectional: there is no required acknowledgement from an Actor that it has received a message. Actors are free to exchange whatever messages their implementation dictates however, including sending acknowledgement messages back to the sender.

In practice, an Actor will perform some sort of application-specific processing when a message is received.

1.2 Actor Addresses

All Actors have an Address which identifies them uniquely within the ActorSystem. The Address of an Actor is assigned by the ActorSystem and should be treated by the Actor as an opaque value.

Actors will communicate with other Actors using the ActorAddress of the other actors. ActorAddress values cannot be synthesized. The ActorAddress of other actors can be obtained in one of two ways:

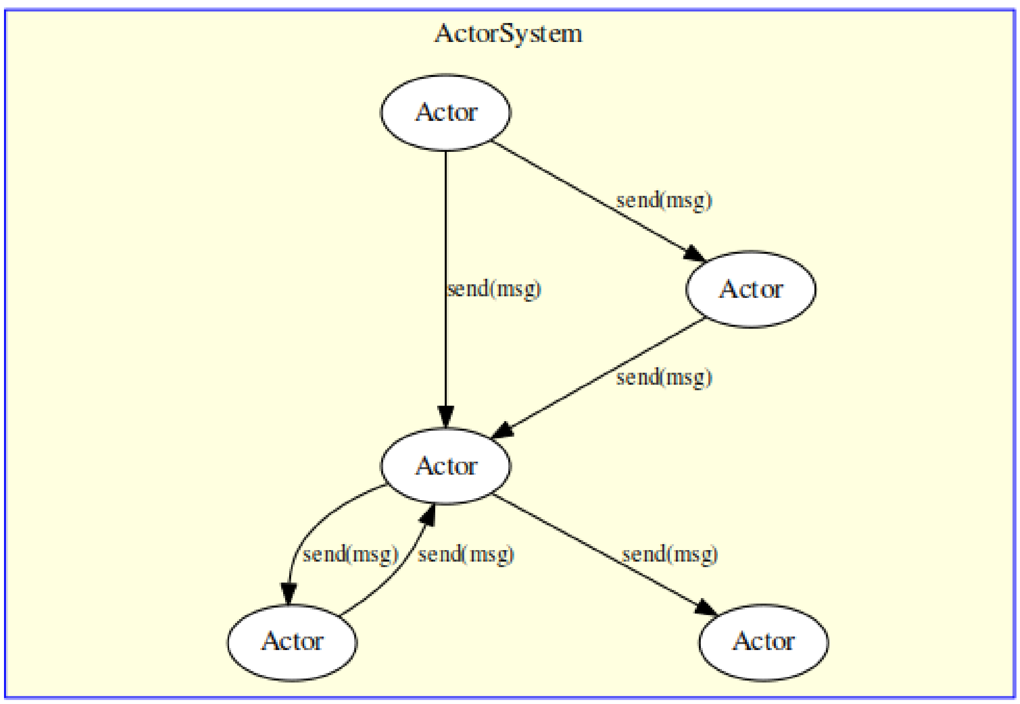
1. The return value from an Actor create request is an ActorAddress
2. Receiving an ActorAddress in a message from another Actor

The actual value of an ActorAddress is determined by the ActorSystem, and varies with the implementation of the ActorSystem and the transport mechanism used. Actors may print the string form of ActorAddresses, and they may compare ActorAddresses for equality or inequality and use them as hash values (e.g. for dictionary keys), but they should not otherwise depend on or attempt to utilize the value of an ActorAddress.

An Actor can refer to its own ActorAddress using the `.myAddress` property.

1.3 ActorSystem

The ActorSystem is the framework within which the Actors reside. The ActorSystem is responsible for Actor lifecycle management (creating and terminating Actors) and message delivery functions.



1.3.1 Different Implementations

There maybe several different types of ActorSystem implementations. Switching from one system to another can be done without requiring any changes to the Actors that run in those systems: the ActorSystem cleanly abstracts the scheduling and message delivery to allow the Actors to be oblivious to those elements.

Each implementation may require a different type of addressing, but as described previously in Actor Addresses the Actors themselves should treat the ActorAddress objects as opaque. In addition, an Actor cannot generate an ActorAddress; it must be given to the Actor as a result of creating an Actor or in a message passed by another Actor.

Not all implementations are equivalent, however. Although all ActorSystem implementations must support the standard Actor API for Actors to use, some implementations do not support specific features or functionality, and some implementations are not suitable for use with the type of applications the Actors implement.

As an example, some ActorSystems will run Actors as multiple threads, whereas other ActorSystems will run Actors as multiple processes.

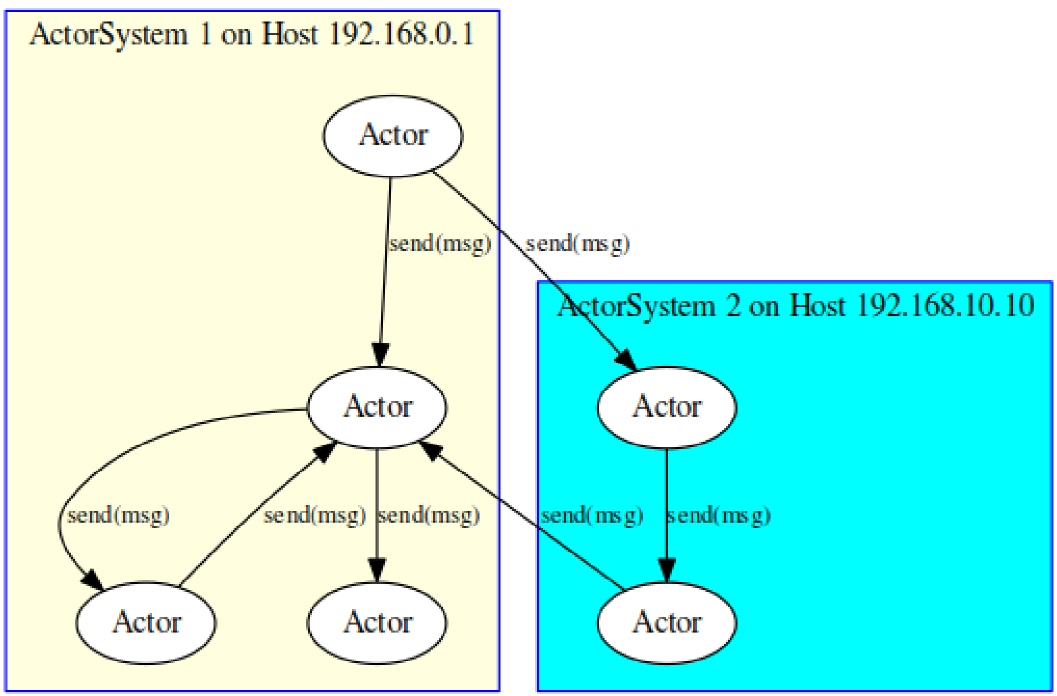
Another example is an ActorSystem that uses TCP networking to communicate between Actors v.s. a system that uses local shared-memory queue structures.

The ActorSystem Implementations section provides detailed information about the known ActorSystem implementations including their level of feature support and any known issues.

1.3.2 Multiple Systems

There can be more than one ActorSystem running on the current host system, and there can be ActorSystems running on other host systems that can coordinate activities with the current ActorSystem.

When Actors are created, they can be created within "remote" ActorSystems. This locality flexibility does not affect each Actor implementation at all: the ActorAddress of an Actor can indicate either a remote or local Actor but the ActorAddress itself is opaque to the Actor.



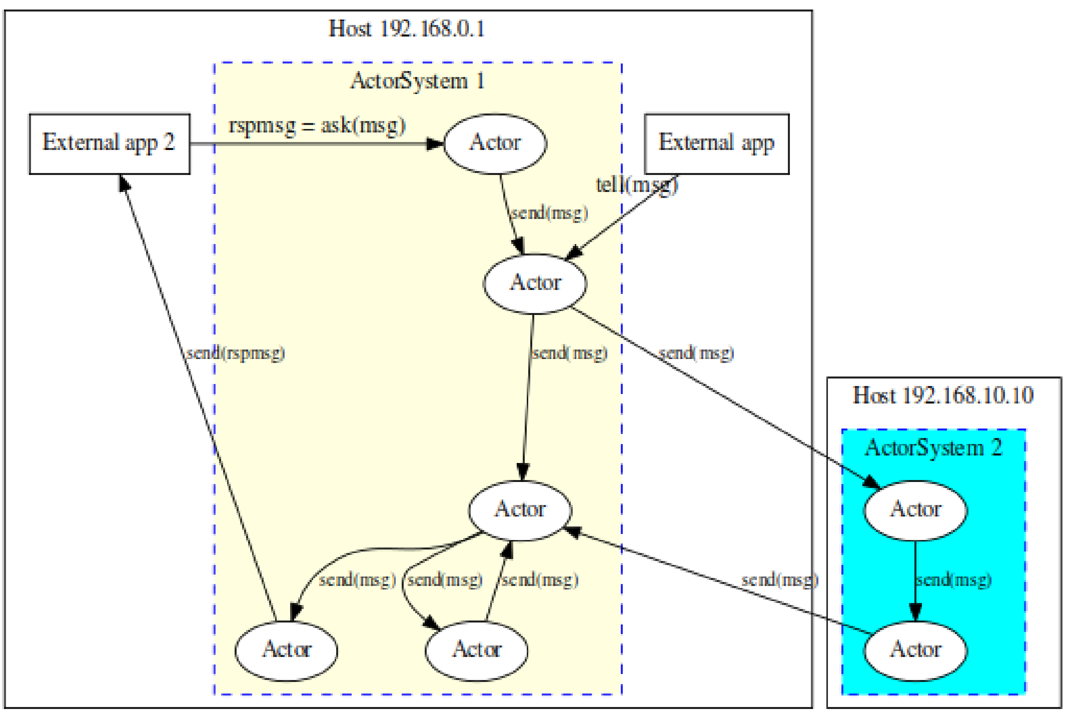
This facility allows for location independence and also provides for essentially unlimited scalability of the underlying support environment.

1.4 External Communications

Actors run in an ActorSystem and communicate with each other using the message sending capability, but it is also typically necessary for the external world to communicate with Actors to initiate activity by those Actors and obtain the corresponding results. This can be done by the external system using the following operations on the ActorSystem itself:

- **tell** – sends a message to a target Actor (as specified by the target Actor's ActorAddress)
- **ask** – sends a message to a target Actor and waits for a message to be sent back.
- **createActor** – creates a new Actor. There is no Parent Actor for the newly created Actor, so it is referred to as a "top-level Actor" and it will be managed by the ActorSystem itself and no other Actor will be notified if the top-level Actor exits.

To the Actor's themselves the messages delivered via the `tell` or `ask` operations appear to have come from another Actor with an ActorAddress. The Actor is unaware that these messages originated from external code.



More details on the ActorSystem operations can be found in the `ActorSystem API` section.

1.5 Effects

Using an Actor system like Thespian tends to be a transformative experience in code generation. Aspects which were previously difficult to work with: multi-processing, concurrency, inter-process communications and networking, scalability, fault tolerance and recovery, ... — all of these are handled by the Actor System itself, allowing the Actors to focus on the primary needs of the application itself.

1.6 Comparisons

1.6.1 Message Bus (Pub/Sub) Architecture

The Actor model provides a higher level of abstraction than a Message Bus architecture (also known as a "pub/sub" architecture). An Actor system can be implemented on top of a message-bus architecture; the Actors themselves are completely unaware of this implementation method.

1.6.2 Logging Systems

Log-based architectures (e.g. Kafka) are fundamentally "pub/sub" architectures that use persistent storage for the published messages. As noted in the Message Bus (Pub/Sub) Architecture, the Actor model is a higher-level abstraction layer that encompasses the pub/sub functionality. The Actor model therefore also abstracts a Logging System with the exception of the persistent storage/replay functionality of the latter.

It is possible to implement message persistence and/or replay functionality for an Actor system by using Actors specifically designed to provide this functionality. The Actor model can thus easily be extended to mimic a Logging System.

2 Using Thespian

In order to use Thespian, it must be installed in the current Python environment. Once installed, all Thespian features are available within Python by simply importing the `actors` module from the `thespian` package:

```
>>> import thespian
```

2.1 Starting an Actor System

An ActorSystem is created simply by instantiating an `ActorSystem()` object and specifying the type or "base" of the ActorSystem, as well as any optional capabilities of that system. For example, to startup an ActorSystem using the "multiprocTCPBase":

```
>>> asys = ActorSystem('multiprocTCPBase')
```

More details on the explicit parameters for this call are found in ActorSystem, and the known system bases are describe in ActorSystem Implementations.

Once created, the running ActorSystem reference is stored as a singleton for the current process by default. This means that subsequent references can either use the direct reference (e.g. `asys` from the above) or another `ActorSystem()` instantiation with no parameters.

2.2 Actor Lifecycle

Actors are created on demand and then persist until they are requested to exit. Actors in a multiprocess System Base are independent of the process that created them and can outlive that process; Actors in a multi-threaded or synchronous System Base exist within the lifetime of the process itself.

Actors exit when explicitly requested to exit, or when the ActorSystem itself is shutdown.

2.2.1 Creating a Top-Level Actor

Actors can be created by other Actors or by external applications making a request to the running ActorSystem. In the former case, the Actor making the request becomes the "Parent Actor" of the newly created Actor, whereas there is no parent in the latter case and the newly created actor is therefore referred to as a "Top-Level" Actor.

A Top-Level Actor is created via the ActorSystem.createActor call:

```
>>> class MyFirstActor(Actor):
...     def receiveMessage(self, message, sender):
...         pass
...
>>> mfa_addr = asys.createActor(MyFirstActor)
```

The result of the call is the ActorAddress which can be used with the ActorSystem's ask() or tell() methods to communicate with the created Actor.

2.2.2 Creating an Actor

Within the ActorSystem, and Actor can create another Actor by making the request to the ActorSystem through the createActor() method on its own instance:

```
>>> class Support(Actor):
...     def receiveMessage(self, message, sender):
...         pass
...
>>> class MyFirstActor(Actor):
...     def receiveMessage(self, message, sender):
```

```
...         if message == 'create another actor':
...             newActor = self.createActor(Support)
```

As with the creation of a Top-Level actor, the `createActor()` method returns an ActorAddress that can be used to communicate with the created Actor (using the current Actor's send() method).

2.2.3 Killing an Actor

Actors normally continue to exist and handle messages until they are explicitly killed. To kill an Actor, it should be sent an ActorExitRequest message.

The Actor will receive that message directly on its `.receiveMessage()` method, which allows the Actor to make any preparations for its demise, but it cannot refuse to exit and it returns from the `.receiveMessage()`, the Actor will be killed by the ActorSystem.

After the Actor has been killed, the Actor's Address is dead-lettered; any subsequent messages sent to the Actor's address will be handled as described in Dead Letter Handling.

2.2.4 Parent Actor

An Actor which creates other Actors automatically becomes the "Parent" of the created Actor(s). In the example in the Creating an Actor section above, the MyFirstActor Actor is the parent of any created Supporting Actor.

The Parent is notified when any child Actors exit. When the Parent is killed, the child Actors are killed by default unless the Parent indicates that they should not be.

Notification of exited children is via the `ChildActorExited` message. This message has the following attributes:

- `.childAddress` to specify the ActorAddress of the child

2.2.5 Actor Failure

If the Actor code handling a message fails, the ActorSystem will automatically handle that failure and restart the Actor. For this reason, Actor-based code is typically much simpler than conventional code because it does not have the overhead of lots of exception checking and error condition handling.

When writing Actor code, the general philosophy is "fail early"; the ActorSystem itself will restart the Actor in the event of a failure and possibly retry the message or abort that specific message. See PoisonMessage Returns for more details.

3 Guidelines for Actors and their messages

- All ActorSystem internal messages are derived from ActorSystemMessage. Messages sent by Actors should not subclass ActorSystemMessage, but Actors may differentiate their messages from Thespian messages by `isinstance()` testing against the ActorSystemMessage.
- Actors should discard messages they do not recognize.
- Actors should allow unexpected or unreasonable exceptions and errors to cause them to fail. The ActorSystem will restart the actor automatically to handle subsequent messages; the message that caused the failure will be returned to the sender.
- All messages sent by the ActorSystem to an Actor are derived from the ActorSystemMessage base class. The messages that an ActorSystem can deliver to an Actor are:
  - ActorExitRequest (see Killing an Actor)
  - ChildActorExited (see Parent Actor)
  - PoisonMessage (see PoisonMessage Returns)
  - ActorSystemConventionUpdate (see Other Actor Systems)
  - WakeupMessage (see Timer Messages)

  Most actors can be written very simply and can safely ignore any and all messages from the ActorSystem. These messages are intended to be useable by more sophisticated Actors to handle unusual or out-of-band events.
- Use simpleActorSystem for easy testing (and automated unit testing). Then use MultiprocQueue for testing with multiple processes to ensure Actor isolation.
- It is a common practice to have an Actor probe for functional aspects of the current environment and update the ActorSystem capabilities based on the results of the probing (see updateCapability). Changing the existing capabilities **may** result in all existing actors being killed, including the Actor initiating the change.

  If the probing Actor is restarted, it has no context regarding the previous probe, but presumably the probe will return the same result as previous, and an updateCapability call that does not actually change capability values does not impact currently running Actors in that ActorSystem. Care should be taken to ensure that the probe Actor reaches a stable condition in this manner.
- Actors are not intended to create other processes or threads; attempts to do so may create undefined behavior.
- Actors should not block indefinitely on IO operations; while the Actor is running in the `receiveMessage()` method it is not able to handle other messages, including Actor System internal messages. The Actor will appear to be frozen and this will result in PoisonMessage delivery failures to Actors attempting to communicate with the busy Actor.

4 Thespian Actor Feature Extensions

The Thespian system provides several extended features not present in a simple definition of an Actor environment. These features provide the additional functionality for error-handling, scalability, and enterprise-level deployment of Thespian-based code.

4.1 Message Delivery

Messages are delivered to Actors on a *best-effort* basis. This means that under normal or even most abnormal circumstances, the ActorSystem effectively guarantees that an Actor's send will reach the intended recipient (eventually). However, under extreme circumstances (grand-mal failure of a multiprocessing system environment, completely hung Actors, etc.) the ActorSystem may not deliver a message; this is why it is classified as *best-effort* instead of *guaranteed delivery*.

When the recipient is busy, the send request is queued in the *sending* Actor's system space. The sending Actor will retry the send periodically. The sending Actor can have multiple messages queued for different targets, but each target is handled independently: messages queued for a target are ordered but messages queued to different targets are handled independently. Eventually the Actor's `.send()` request *will* block if there are too many messages queued for the intended target. This queueing mechanism provides a "back-pressure" mechanism throughout the system to prevent too many messages being held in limbo.

If the recipient exits before the send can be completed, the message is redirected to Dead Letter Handling.

4.1.1 Message Mutability

Thespian does not automatically generate copies of messages that are sent, but sends the original directly. This covers most use cases and has performance advantages in avoidance of extra copying, but it does expose a potential for leakage of information between Actors in some implementations.

```
class MyActor(Actor):
    def receiveMessage(self, message, sender):
        ...
        self.send(actor2, NewMessage(...))
        ...
```

The above example shows a common use case where the message to be sent is generated directly, and no longer used or referenced by the sending Actor after the `.send()` call. This pattern is entirely safe in all instances. However, if the sending Actor maintains a reference to the sent message, as in the example below, the sending Actor's copy **may** be modified by code in the recipient.

```
class ActorA(Actor):
    def receiveMessage(self, message, sender):
        ...
        actorb = self.createActor(ActorB)
        newmsg = NewMessage(foo="foo")
        self.messages.append(newmsg)
        self.send(actorb, newmsg)
        ...
        for each in self.messages:
            assert each.foo == "foo"

class ActorB(Actor):
```

```
13      def receiveMessage(self, message, sender):
14          message.foo = "bar"
```

In the example shown above, the assertion in line 10 may fail because ActorB has modified ActorA's original copy in line 14. Whether or not modification of ActorA's copy occurs is based on timing of execution between the two actors, and also on the system Base that is used. When using a multi-process system base, ActorA's version will not be modified because the two Actors run as separate processes and so ActorB has a separate copy of the message, but the simpleSystemBase (for example) is exposed to this modification.

If an Actor references a message post-send, it should be aware of this potential. The mutation may be avoided by ActorA sending a copy of the original message (`self.send(actorb, copy.deepcopy(newmsg))`), although this has negative performance implications (which is why Thespian does not automatically perform this copy).

4.2 Dead Letter Handling

If the ActorSystem is unable to deliver a message to the target Actor (usually because the target Actor has been killed or otherwise exited), the ActorSystem will route that message to Dead Letter handling. The routed message will be wrapped in a DeadEnvelope message to indicate it's disposition.

By default, the Dead Letter handling will discard the message in question (possibly logging the event).

It is possible for an Actor to register for handling Dead Letters. In this case, the dead-letter handling Actor receives all messages that could not be delivered to their target address.

Dead letter handling should be considered as a fail-safe to prevent messages from getting lost, but it is recommended that Actors update their knowledge about other Actors that no longer exist and cease sending messages to those other Actors. One reason for this is that the address of the Actor that no longer exists may—at some point—be assigned to a new and completely different Actor; if the original Actor persisted in sending messages to the dead Actor, those messages would eventually start being routed to the new Actor, which would undoubtably cause confusion.

4.3 Non-startable Actors

Actors that cannot be started at all will be Dead Lettered by the ActorSystem. If an Actor has registered for receiving Dead Letters (see Dead Letter Handling) then it can perform special actions to handle the non-starting Actor, but by default all messages sent to a non-starting Actor are discarded by the default Dead Letter Handling.

4.4 PoisonMessage Returns

If an Actor experiences a failure (an uncaught exception) when processing a message, the ActorSystem will catch the exception and retry delivery of the message to the target Actor (as describe in Actor Failure).

If the target Actor generates another exception when handling the message the second time, the ActorSystem will assume that the message has caused the failure and will wrap the message in a `PoisonMessage` wrapper object and send it back to the sender of the original message. The Actor experiencing the exception is still live, and other messages will still be delivered to it.

See PoisonMessage for details on the `PoisonMessage` object.

4.5 Top-Level Actors

Actors created by the external environment are called "Top-Level Actors" and are unique in that they have no "parent" Actor (see Parent Actor). Since there is no Parent Actor, there is nowhere to send a ChildActorExited message when the Actor dies and therefore there is no allowance for restarting Top Level Actors.

Messages sent to a Top Level Actor that has died will still be redirected to the Dead Letter Handler (see Dead Letter Handling).

4.6 Named Actors

Most Actors are created and subsequently referenced by the ActorAddress. This ActorAddress can be used by any Actor in the system to send a message to that created Actor.

At times, however, it may be convenient to very explicitly refer to a single Actor in the entire system—a Singleton—without knowing the Address of that Actor. To support this, Thespian allows the creation of "Named Actors" where the name given uniquely identifies the Actor.

The initial Actor creation request with the name will create the requested Actor, but the Actor System will remember the Actor associated with that name andall subsequent Actor creation requests with the same name will return the originally created Actor.

It is possible to create any number of Named Actors in the system, although it is the responsibility of the creators to manage the namespace of those Actors.

There are a couple of disadvantages to Named Actors that must be considered relative to their convenience:

1. All Named Actors are similar to Top-Level Actors in that they are managed by the Actor System itself rather than a Parent Actor and therefore there is no notification when a Named Actor exits, and any messages sent to a Named Actor that has exited will be sent to the Dead Letter Handler.
2. Interaction with Named Actors can be slower than for standard Actors because of the need to perform global lookup and coordination based on the name.

It is recommended (but not required) that only the top-level, coordinating Actors be Named Actors and that most Actors in the system be

4.7 Timer Messages

Normally Actors respond to messages sent to them by other Actors, but sometimes an Actor would like to run again after a timed delay. While it is possible for the Actor to sleep internally, this will prevent it from responding to other messages and cause messages to be queued causing eventual delivery failure (see Message Delivery).

To avoid this, each Actor has a `.wakeupAfter()` method that can be called with a specified Python `timedelta` value. The ActorSystem will schedule the delivery of a `WakeupMessage` after that time period has elapsed. Multiple wakeups can be pending for an Actor at any single time, and the delivery of the `WakeupMessage` is interleaved into the normal incoming message stream for the Actor.

There is no provision for cancelling a pending wakeup; the Actor should simply ignore the `WakeupMessage` when it is received.

4.8 Watching File Descriptors

The Actor model itself is a pure specification that is good for concurrent computational tasks, but real-world Actors must often interact with or control the external world via sockets, files, or other interface elements.

One way to accomplish this is to use the `.wakeupAfter()` functionality described in the previous section to periodically run the Actor, whereupon it may check to see if there is any pending I/O for these interface elements. Each interface element should be accessed in "non-blocking" mode so that the Actor itself can exit immediately if there is no work to be done (thereby allowing the Actor to process new messages as soon as they are received). The http_server1.py file is an example of a simple HTTP server based on this model.

The above model is fairly limited however: it is essentially a busy-wait loop that consumes resources even when there is no work to do, and its responsiveness is limited by the period of the wakeup calls. An alternative approach provided by *some* Thespian SytemBases is the "Watch" extension (as indicated by a System Capability of "Thespian Watch Supported" with a value of True).

When using the Watch extension, the Actor should return a `ThespianWatch` object each time its `.receiveMessage()` method is called. The `ThespianWatch` object is initialized with a list of file descriptors (from sockets or files) that should be watched, and if any of these have readable data, the Actor will be called with a `WatchMessage` message. The `WatchMessage.ready` member is a list of the supplied file descriptors that can be read from. The `ThespianWatch` is **only** valid for that single return from the Actor's `.receiveMessage()` call, and it must be supplied each time the `.receiveMessage()` returns to specify any file descriptors that should be watched during the wait for the next `.receiveMessage()` invocation.

The http_server2.py file is an example of a simple HTTP server that is similar to the http_server1.py but this example is modified to use the Watch extension.

The Watch extension has a number of limitations:

1. It is not available for all ActorSystem bases (only those with a system capability of "Thespian Watch Supported" where the value is True).
2. It is OS-dependent: on Linux, any file object may be watched, but on Windows only sockets may be watched.
3. It only watches for "readable" events, not writable or exception events.
4. It implies the use of `select.select()`.
5. There is no timeout (use `.wakeupAfter()` for this).

Writing Actors which utilize the Watch extension may siginificantly limit the portability of these Actors.

4.8.1 Blocking Actors

There are some cases where the desired functionality of the Actor is to actually block on external operations. For example, an Actor that acts as a client making calls to an external service might be best written to block on those external calls. When the Actor blocks, other Actors cannot deliver messages to that Actor and backpressure builds (see Message Delivery for more details).

The effect of this blocking functionality is to regulate the number of requests to the external service. If the Actor performed non-blocking requests to the external service, it could flood the service with large numbers of requests.

The disadvantage of the blocking approach is that the Actor is unresponsive while blocked on the external service call. More sophisticated methods involving internal queueing and timeouts could be used as well.

4.9 Actor Troupes

If specified appropriately, multiple instances of an Actor can be created which share the same ActorAddress; this is known as an Actor Troupe.

- Messages sent to the ActorAddress associated with the Troupe may be handled by any of the members of the Troupe,
- A message will be delivered to only one member of the Troupe, but the handling of that message will be performed independently and asynchronously to any other message being handled by a member of the Troupe.
- All members of the Troupe are local to each other (i.e. exist under the same ActorSystem).

The Actor Troupe allows for scalability and parallelization of individual Actor functionality. Conversely, the use of a single Actor (instead of a Troupe) ensures single-threaded, synchronous handling of messages for that Actor.

4.10 ActorSystem Capabilities

Actors can stipulate the requirements of the ActorSystem that they will run in by matching "Capabilities" of the ActorSystem. Each ActorSystem has a set of Capabilities specified as a key/value dictionary. This dictionary is passed to an Actor's `ActorSystemCapabilityCheck()` static method, which examines the capabilities and returns `True` or `False` to indicate whether or not the current ActorSystem is viable for the Actor.

If the current ActorSystem is rejected for creating the Actor, the ActorSystem will pass the Actor Create request to other ActorSystems to see if any of those systems can create the requested Actor.

The Capabilities of an ActorSystem are free form and the actual capability keys and values are determined by whatever agent specifies them.

All Thespian ActorSystem instances automatically supply a set of common capabilities described in the Common Capabilities section.

4.11 Other Actor Systems

The current ActorSystem can communicate with other ActorSystems to coordinate Actor activities as described in Multiple Systems. To support this, the ActorSystems communicate on known transport addresses to form a "Convention" of ActorSystems.

When new Actors are created, the ActorSystem Capabilities of the ActorSystems that are part of the Convention are used to determine where to start up the requested new Actor.

Remote ActorSystem implementations can be different than the local ActorSystem as long as they properly handle communications between the two ActorSystems and the Actors contained therein.

Actors can also register to be aware of when remote ActorSystems enter or exit the convention. Registered Actors will receive an ActorSystemConventionUpdate message for these events. Actors register for these updates using the notifyOnSystemRegistrationChanges API call.

Not all ActorSystems support multi-system communications, and those that do are normally of the multi-process variety.

4.12 Logging

The standard Python logging can be used with the Thespian Actor system, although there are some Thespian modifications to logging that improve the logging experience using Thespian.

The optional `logDefs` argument passed to the `ActorSystem()` instantiation (see below) will specify the primary logging configuration for Thespian and corresponding Actors (regardless of where the logger is obtained).

The functionality provided by logging in the Thespian environment possibly includes sending log messages to a central Logging actor (as explicitly indicated in the ActorSystem Implementations section). This is needed because the standard Python logging is not multi-process safe and attempts to use it as-is will result in missing or duplicated log messages.

In addition, the Convention Manager Actor System receives all log messages from any conference member that is of `WARNING` level or above.

Once the logging configuration has been specified in the `ActorSystem()` call, the normal python logging library can be used to generate logging.

Log output generated by Actors may automatically have an "actorAddress" attribute added, which can be referenced by the log formatter (in the same manner as the standard attributes such as "levelname" and "message"). The "actorAddress" attribute is not always present because some logging can be generated externally to the actors; the formatting operation cannot account for this, so a filter should be used to ensure the right formatter is specified.

For example:

```
import logging

class actorLogFilter(logging.Filter):
```

```
    def filter(self, logrecord):
        return 'actorAddress' in logrecord.__dict__
class notActorLogFilter(logging.Filter):
    def filter(self, logrecord):
        return 'actorAddress' not in logrecord.__dict__

logcfg = { 'version': 1,
           'formatters': {
               'normal': {'format': '%(levelname)-8s %(message)s'},
               'actor': {'format': '%(levelname)-8s %(actorAddress)s => %(message)s'}},
           'filters': { 'isActorLog': { '()': actorLogFilter},
                        'notActorLog': { '()': notActorLogFilter}},
           'handlers': { 'h1': {'class': 'logging.FileHandler',
                                'filename': 'example.log',
                                'formatter': 'normal',
                                'filters': ['notActorLog'],
                                'level': logging.INFO},
                         'h2': {'class': 'logging.FileHandler',
                                'filename': 'example.log',
                                'formatter': 'actor',
                                'filters': ['isActorLog'],
                                'level': logging.INFO},},
           'loggers' : { '': {'handlers': ['h1', 'h2'], 'level': logging.DEBUG}}
         }
```

This logging configuration complexity is unfortunately imposed by the need to select the proper formatter, but this complexity can be captured in an auxiliary file and is only needed for passing to the `ActorSystem()` instantiation.

4.12.1 Thespian Internals Logging

Because Thespian instruments the standard logging functionality to provide the Convention forwarding ability, it is not possible to use logging from within most of Thespian itself because this can cause infinite recursions hangs.

Thespian internals write logging information to a file (`/tmp/thespian.log` by default) with a single backup rotation of that file at a specified size limit. This internal logging can be controlled via the following environment variables that must be set before the ActorSystem is started:

THESPLOG_FILE specifies the filepath for the Thespian internals logging. By default this writes to `/tmp/thespian.log`.

THESPLOG_FILE_MAXSIZE specifies the maximum size for the Thespian internals logging file. There is a single backup rotation (`{filepath}.old`), so the actual space consumed can reach twice this value. The default value of 50KB is relatively small, but this file should normally not be needed by developers writing Actors and is usually only needed by developers modifying Thespian internals.

4.13 Actor Code Distribution

The Thespian ActorSystem provides an feature to specify the code used for Actor implementations.

By default, an Actor implementation is obtained by importing from the current environment and then passing that object to a `createActor()` call. When used in this default manner, all of the `.py` sources used to implement Actors must be in the import path of the Thespian ActorSystem itself.

With the Code Distribution feature provided by Thespian it is possible to load specific Actor code as provided by a (possibly encrypted) zipfile. The zipfile can be dynamically loaded into an already-running Thespian ActorSystem. This provides a number of advantages:

- The Thespian ActorSystem can be distributed and activated as a standalone element. The code for Actors to be run within the system can be distributed separately.
- Actor implementation code can be protected by encryption, allowing that code to run only when the proper decryption key is provided. This provides both distribution security (Python source files are not readable by anyone with access to the computer on which they are installed) and validation of authorization to interact with and execute the Actor code (especially in cases where the ActorSystem runs with elevated privileges).
- Multiple unrelated sets of Actors can share the same ActorSystem without adverse interactions.
- Running Actor implementations can be updated without requiring the entire ActorSystem to be stopped and restarted. This is especially useful when the ActorSystem is hosting multiple different and independent sets of Actors.
- Multiple instances of the same set of Actors can be running in the same ActorSystem simultaneously. This is especially useful when upgrading to a new version of a set of Actors where all new messages are directed to the new Actors while allowing all messages circulating between the older Actors to drain; in this scenario there is no downtime to customers when upgrading an Actor implementation.

When the Thespian Actor Code Distribution mechanism is used in a multi-ActorSystem configuration (e.g. cooperating ActorSystems between several computers), it is only necessary to load the zipfile into one ActorSystem. The different ActorSystems will automatically pull the zipfile from the source system to support a createActor operations that would occur in that other ActorSystems (e.g. due to system capabilities or actor requirements). This mechanism allows the following additional benefits:

- Actor code distribution can be done by simply loading the new code version into a single ActorSystem (usually the convention leader) and all other ActorSystems will automatically update with that code on an as-needed basis.
- Actor implementation synchronization. The createActor will automatically synchronize the current zipfile version to the target ActorSystem before instantiating the new Actor, thereby ensuring that the local Actor is communicating with an up-to-date version of the remote Actor. There is no longer a risk that a newer version of an Actor will attempt to communicate with a remote Actor instance that is out-of-date and encounter version-related problems.

The loadActorSource operation describes this capability in more detail, including security protections associated with this feature.

5 Actor API

The Actor API is the set of operations that a running Actor can perform. Thespian implements this API as a set of methods on an `Actor` baseclass that all running Actors should subclass.

The Actor API is made available by importing the `thespian.actors` module.

Each Actor is represented by an Actor baseclass:

```
from thespian.actors import Actor

class MyActor(Actor): ...
```

Versioning of the Actor API and the ActorSystem are described in ActorSystem Capabilities.

5.1 myAddress

```
self.myAddress
```

This property is the ActorAddress of this Actor.

5.2 receiveMessage

```
def receiveMessage(self, message, sender): ...
```

This method is the primary entry point into the Actor to handle received messages. Each subclass should override the base Actor receiveMessage() method as appropriate. The `message` argument is the message being received, and the `sender` is the ActorAddress of the Actor (or External Communications endpoint) sending the message.

The message can be discarded once it has been handled. As described previously in Actors, there are three things an Actor can do when handling a message:

1. Update internal state
2. Create a finite number of other Actors
3. Send a finite number of messages to other Actors

If the processing of the message causes an exception, the failure will be caught by the ActorSystem and the message may be retried or returned to the sender as described in PoisonMessage Returns. Note that the *original* copy of the receive message is passed to the Actor with each attempt; if the Actor modifies the message before failing with an exception, the retried or Poison-returned version will contain the modifications made by the original attempt.

5.2.1 Return Value

Ordinarily the return value from an Actor's `receiveMessage()` method is ignored, but if the underlying ActorSystem implementation supports the Thespian Watch extension (see Watching File Descriptors) then the Actor may return a ThespianWatch object which specifies a list of the file numbers to watch for incoming data; the Actor's `receiveMessage()` will subsequently be passed a WatchMessage with the file number(s) for which data is available.

Any other value or object returned from `.receiveMessage()` will be ignored.

The object is initialized with the list of file numbers to watch for incoming data from.

```
from thespian.actors import Actor, ThespianWatch

class MyActor(Actor):
    def receiveMessage(self, message, sender):
       ...process message...
       return ThespianWatch([self.socket1.fileno(),
                             self.socket2.fileno()])
```

Any invalid or closed file descriptors will be ignored. The file descriptors are watched only until the next call to the Actor's `.receiveMessage()` method, so each call to this method must return the set of file descriptors that should be watched when it exits.

5.3 createActor

```
    newAddress = self.createActor(self, actorClass,
                                  targetActorRequirements=None,
                                  globalName=None)
```

This method is called by the Actor to create a new Actor represented by the specified `actorClass`. The `actorClass` may be specified as either a class object or as a module-qualified string (e.g. ~"foo.bar.BarActor"~ will search for `class BarActor` in the `bar.py` in the `foo` directory). The InvalidActorSpecification exception will be thrown if the actorClass is not specified in a valid manner.

The optional `targetActorRequirements` argument is a value that will be passed passed to the actorSystemCapabilityCheck to use for validating whether the Actor can be started within the current ActorSystem environment (see ActorSystem Capabilities). The value specified for this argument can be anything the target Actor's `actorSystemCapabilityCheck()` method can understand, although typically it is a Python dictionary.

The `globalName` argument may be specified (as an arbitrary string) to create a Named Actors instance.

The context for the created Actor will be the context under which the Thespian system was started. <u>This means that if the Thespian system was started as root, then all Actors will run as root.</u>

The source for the `actorClass` to be created is established by the current Actor, relative to any loadActorSource operation that apply to the creating Actor itself:

- If an Actor class is specified directly, that class is obtained via import operations. These import operations use the lookup search path that already use a searchpath that contains any loaded actor source operations.
- If a module-qualified string specifies the `actorClass`, then the lookup of that class will use the same source hash lookup path that the Actor itself came from.
- It is not possible to specify an alternate source file hash when performing a `createActor()` call from within an Actor (only the ActorSystem `createActor()` method can do that).
- If the target Actor must be instantiated in a separate ActorSystem and that ActorSystem does not have the loadActorSource for the target Actor available, it will automatically obtain that loadActorSource file from the current system and then start the target Actor from that source. This can be used as a code distribution methodology for the ActorSystems' environment. The ActorSystem that initiated the `createActor()` call with the hash must already have that source loaded.

The return value of this method is the ActorAddress of the newly-created Actor. Note that this address may be provided even before the target Actor is instantiated and is ready for handling messages. The ActorSystem will automatically buffer any messages sent to the new Actor until that Actor is ready; the creating Actor is free to send messages immediately on completion of this request and does not need to be concerned with the asynchronous startup aspect of the target Actor. However, due to this asynchronous startup, it is possible that the new Actor cannot be started at all; in this event all messages intended for the new target Actor will be handled as described in the Dead Letter Handling section.

5.3.1 globalName

The parent for a Named Actor (created when the `globalName` argument is specified) is the ActorSystem itself, rather than the requesting Actor. This is because there may be multiple createActor requests for the same global name and they should all return the Address of the same Actor, but an Actor cannot have multiple Parents.

A Named Actor persists as long as it is not killed (via an ActorExitRequest) and can be referenced by any Actor requesting a create with the same globalName.

When a Named Actor exits, only the ActorSystem is aware of the exit; there is no ChildActorExited notification sent to any Actors that requested the creation of the Named Actor.

5.3.2 Actor Creation Gotchas

There are a few issues to be aware of when creating Actors:

1. When creating an actor using a string specification of the Actor Class, the name **must** be a fully-qualified module specification and not simply the name of an ActorClass in the current source.

   While the latter would be convenient, it is not possible for remote processes to have access to the current source frame to load these Actors. One solution is to use a class reference rather than a string (but see the next issue).

   The InvalidActorSpecification exception will be thrown if the actorClass is not specified in a valid manner.

2. Actor classes must either have been in the system path when the ActorSystem was created, or they must exist in a loaded Actor Source (see loadActorSource). Many ActorSystems use separate processes to manage and create new Actors, so any changes in the current process after the ActorSystem process is started up will not be visible to the latter.

5.4 send

```
self.send(self, targetAddress, message)
```

This is the method used to send a message from the current Actor to another Actor as identified by the `targetAddress`. The `message` can be anything the current Actor desires, although most ActorSystem implementations will require that the `message` can be pickled by the Python `pickle` utility.

There is no response to the send, and the message is delivered to the target asynchronously. There is no guarantee that the target has received the message by the time the `.send()` method returns. The ActorSystem delivers the message at some point by best-effort, sending the message to Dead Letter Handling if it cannot be delivered.

5.5 wakeupAfter

```
self.wakeupAfter(self, timePeriod)
```

The `timePeriod` specifies a Python `datetime.timedelta` period. When this time period has expired, the ActorSystem will deliver a `WakeupMessage` to the Actor via the normal `.receiveMessage()` entrypoint (the sender will be the Actor itself). See Timer Messages for more information.

5.6 handleDeadLetters

```
self.handleDeadLetters(self, startHandling=True)
```

This method can be called to register or de-register this Actor for handling Dead Letters.

5.7 notifyOnSystemRegistrationChanges

```
self.notifyOnSystemRegistrationChanges(self, startHandling=True)
```

This method can be called to register or de-register this Actor for handling system registration events from other ActorSystems (see Other Actor Systems) via ActorSystemConventionUpdate messages.

5.8 registerSourceAuthority

```
self.registerSourceAuthority(self)
```

This method registers the current Actor as the Source Authority handler for the current Actor System as described in the Security Considerations section of the loadActorSource Actor System API call. Once registered, this Actor will receive ValidateSource messages and be responsible for decrypting (if necessary) and determining authorization for loaded sources to run.

The current Actor continues as the Source Authority until another Actor registers for this role.

5.9 loadActorSource

```
sourceHash = self.loadActorSource(fileref)
```

The `loadActorSource()` method is used to load a (possibly encrypted) zipfile containing Python source code in standard Python zipimport format (via PEP302[1] methodologies). The return value is an internally-generated hash value identifying that loaded source zipfile that can be used in subsequent createActor calls to instantiate Actors found in that sourcefile.

There must be a valid Source Authority registered (via the registerSourceAuthority method) to validate the loaded source; by default this method does nothing if no Source Authority has been loaded. See Security Considerations for more information.

See the description of the same function in the ActorSystem API section for more details.

5.10 unloadActorSource

```
self.unloadActorSource(sourceHash)
```

The `unloadActorSource()` method is used to unload a source zipfile previously loaded by the loadActorSource operation.

See the description of the same function in the ActorSystem API section for more details.

5.11 actorSystemCapabilityCheck

```
def actorSystemCapabilityCheck(capabilities, requirements=None):
    return True
```

[1] The PEP302 Python extension specification defines the ability to add a custom package finder/loader that coordinates with the Python `import` statement. The Thespian `loadActorSource` implements a PEP302-compliant package manager. All loaded packages are prefixed with their source hash to ensure namespace uniqueness.

This is a **static** method provided by the Actor object that is called to see if the Actor can be created within the context of the current ActorSystem.

The `capabilities` argument specifies the key/value dictionary of capabilities of the current ActorSystem. ActorSystem capabilities are free-form and are determined solely by agents specifying those capabilities (see ActorSystem Capabilities).

The optional `requirements` argument specifies the additional requirements that the creating Actor specified in the `.createActor()` call.

The `.actorSystemCapabilityCheck()` should return `True` to indicate that the Actor may be created in the current ActorSystem, or `False` to indicate otherwise. It is free to base this decision on any, all, or none of the capabilities or requirements provided.

This static method may also be called to re-validate the Actor's viability if the capabilities of its ActorSystem are updated (as described in the updateCapability section), and if it returns False then the existing Actor will be killed with an ActorExitRequest message.

5.11.1 requireCapability decorator

To facilitate easy specification of requirements, there is a `requireCapability` class decorator defined which can be used to specify that a capability must be present in the system capabilities.

```
@requireCapability(capabilityName[, capabilityValue])
```

The `requireCapability` decorator can also specify a value for the capability; if no value is specified then the capability's value must be "truthy" (i.e. some expression that evaluates as truthful).

The decorator can be repeated multiple times for a single Actor and it may be used in conjunction with an actual `actorSystemCapabilityCheck()` method.

For example:

```
class MyActor(Actor):

    @staticmethod
    def actorSystemCapabilityCheck(capabilities, requirements):
        return capabilities.get('Has Lightbulb', False) and \
               capabilities.get('Lit', False) and \
               capabilities.get('Color', 'none') == 'Yellow'

    def receiveMessage(self, msg, sender): pass
```

is equivalent to the following combined use:

```
@requireCapability('Has Lightbulb')
```

```
@requireCapability('Lit')
class MyActor(Actor):

    @staticmethod
    def actorSystemCapabilityCheck(capabilities, requirements):
        return capabilities.get('Color', 'none') == 'Yellow'

    def receiveMessage(self, msg, sender): pass
```

or the equivalent use of only the decorator:

```
@requireCapability('Has Lightbulb')
@requireCapability('Lit')
@requireCapability(Color', 'Yellow')
class MyActor(Actor):

    def receiveMessage(self, msg, sender): pass
```

In the above examples, the `MyActor` Actor can be instantiated in an ActorSystem that had the capabilities of:

```
{
  'Has Lightbulb': 5,
  'Lit': True,
  'Color' : 'Yellow'
}
```

Note that the value of 5 is "true", as compared to a value of 0 that is "false". Any value that would represent as true in an **if** expression is a valid value.

An example of a much simpler case:

```
class MyActor(Actor):

    @staticmethod
    def actorSystemCapabilityCheck(capabilities, requirements):
        return capabilities.get('Has Lightbulb', False)

    def receiveMessage(self, msg, sender): pass
```

is equivalent to:

```
@requireCapability('Has Lightbulb')
class MyActor(Actor):

    def receiveMessage(self, msg, sender): pass
```

5.12 updateCapability

The `updateCapability()` method is used update the capabilities of the current ActorSystem this Actor is running in (there is a corresponding method on the ActorSystem for externally-specified updates; see the ActorSystem API for that version).

```
self.updateCapability(self, capabilityName, capabilityValue=None)
```

If the capability value is specified and is not None, the specified capability already exists, its value updated, otherwise it is created with the specified value.

If the capability value is not specified or is None, the specified capability is removed from the ActorSystem if it exists.

If the capabilities of the ActorSystem are modified by this method (i.e. the capability value is not already set as requested) then all Actors within that ActorSystem are re-validated by calling their actorSystemCapabilityCheck static method and sending them an ActorExitRequest if the capability check call returns false. This could result in killing the Actor that initiated the capability exchange, even if new capabilities are added. Actors may be recreated as desired; the new Actors will validate against the new set of capabilities.

The current set of ActorSystem capabilities can be obtained by issuing a Thespian_StatusReq to the ActorSystem.

5.13 preRegisterRemoteSystem

The `preRegisterRemoteSystem()` method is used to inform the local Actor System about a remote Actor System.

This method is normally not used or needed, and should be avoided if possible.

Normally Actor Systems will communicate with each other and automatically perform discovery, and Actors themselves should not be aware or involved this functionality.

However, there are certain transport configurations where this auto-discovery is not possible. In these configurations, this method can be used to initiate communications between the two Actor Systems. This method will only work for Actor System bases that support Conventions (as describe in the Other Actor Systems section).

Because the remote Actor System and the local Actor System cannot perform auto-discovery, the local system also assumes responsibility for actively initiating convention membership checks of the pre-registered remote system. These pre-registration checks will continue to occur periodically until the pre-registered remote member is removed (via the `deRegisterRemoteSystem()` method described below). The current system will also automatically become the Convention Leader for the remote system.

```
self.preRegisterRemoteSystem(self, remoteSystemAddress,
                             remoteSystemCapabilities)
```

The `remoteSystemAddress` parameter is not a true Actor Address: it specifies the remote system address in string format in a syntax that will be interpreted by the local Actor System. If the specified string is not recognizeable by the local Actor System, no Convention membership will be added. For example, the multiprocTCPBase and multiprocUDPBase system bases can recognize "ipaddr:port" formats.

The `remoteSystemCapabilities` parameter specifies a dictionary of the initial remote system capabilities. These capabilities will be updated with actual capabilities once the two systems have established communications.

5.14 deRegisterRemoteSystem

The `deRegisterRemoteSystem()` method is used to unregister a previously registered remote system. This method is the counterpart to the `preRegisterRemoteSystem()` method and has all the same warnings and caveats that apply to the latter.

If the remote Actor System is still running and communicating with the local Actor System then it will automatically re-register itself despite having been de-registered by this method.

If there is no remote Actor System registered for the specified address, or if the address cannot be successfully recognized by the local Actor System, this method will simply return with no effect.

```
self.preRegisterRemoteSystem(self, remoteSystemAddress)
```

The `remoteSystemAddress` parameter is specified in the same manner as for the `preRegisterRemoteSystem()` and is usually the same value that was originall passed to the latter method.

5.15 ActorTypeDispatcher

An alternative base class for creating Actors is the `ActorTypeDispatcher` which extends the `Actor` base class. The `ActorTypeDispatcher` automatically determines the type of incoming messages and calls a receive method related to that type instead of the generic `receiveMessage()` called by the Actor base class. The type-based receive methods are named "receiveMsg_TYPE" where TYPE is the actual type.

```
class Typer(ActorTypeDispatcher):

    def receiveMsg_str(self, message, sender):
        self.send(sender, "Got a string")

    def receiveMsg_int(self, message, sender):
        self.send(sender, "Got an int")
```

This dispatching works for user-defined classes as well as built-in types, and will iterate through the base classes if a higher-level handler is not found.

```
class BaseMsg(object): pass
```

```
class ShortMsg(BaseMsg):
    def __init__(self, report = ''):
        self.report = report

class LongMsg(BaseMsg): pass


class Typer(ActorTypeDispatcher):

    def receiveMsg_str(self, message, sender):
        self.send(sender, "Got a string")

    def receiveMsg_int(self, message, sender):
        self.send(sender, "Got an int")

    def receiveMsg_LongMsg(self, message, sender):
        self.send(sender, "Got a long message")

    def receiveMsg_BaseMsg(self, message, sender):
        self.send(sender, "Got a message")


>>> asys = ActorSystem()
>>> t = asys.createActor(Typer)
>>> print(asys.ask(t, 1))
Got an int
>>> print(asys.ask(t, "1"))
Got a string
>>> print(asys.ask(t, LongMsg()))
Got a long message
>>> print(asys.ask(t, ShortMsg()))
Got a message
>>>
```

This receive method lookup also works for derived classes:

```
class Subtyper(Typer):
    def receiveMsg_ShortMsg(self, message, sender):
        self.send(sender, "Got a short message")


>>> asys = ActorSystem()
>>> a1 = asys.createActor(Typer)
>>> print(asys.ask(a1, ShortMsg()))
Got a message
>>> print(asys.ask(a1, LongMsg()))
Got a long message
>>>
>>> a2 = asys.createActor(Subtyper)
```

```
>>> print(asys.ask(a2, ShortMsg()))
Got a short message
>>> print(asys.ask(a2, LongMsg()))
Got a long message
>>>
```

It is possible to specify a fallback handler for the `ActorTypeDispatcher` if the type is not explicitly recognized by defining the `receiveUnrecognizedMessage()` method.

```
class Subtyper2(Typer):

    def receiveMsg_ShortMsg(self, message, sender):
        self.send(sender, "Got a short message")

    def receiveUnrecognizedMessage(self, message, sender):
        self.send(sender, "Did not recognize the message type: %s"%type(message))
```

```
>>> asys = ActorSystem()
>>> st = asys.createActor(Subtyper2)
>>> print(asys.ask(st, ShortMsg()))
Got a short message
>>> print(asys.ask(st, 1))
Got an int
>>> print(asys.ask(st, 1.0))
Did not recognize the message type: <type 'float'>
>>>
```

5.15.1 Type Handling Deferral

In a normal Python subclass, it is possible for a method in the subclass to call a method in the base class by using the `super()` function:

```
class ClassA(object):
    def method1(self): pass

class ClassB(object):
    def method1(self, val):
        if val == 1: pass
        super(ClassB, self).method1()
```

However, this `super()` technique is not as useful when using the `ActorTypeDispatcher` because it only looks for the specifically identified method, which would abort the receive handler search operation implemented by `ActorTypeDispatcher`:

```
class SubTyper3(Typer):
```

```
    def receiveMsg_ShortMsg(self, message, sender):
        if "private" in message.report:
            super(SubTyper3, self).receiveMsg_ShortMsg(self, message, sender)
        else:
            self.send(sender, "Got a public short message")
```

```
>>> asys = ActorSystem()
>>> st = asys.createActor(SubTyper3)
>>> print(asys.ask(st, ShortMsg("This is public")), 2)
Got a public short message
>>> print(asys.ask(st, ShortMsg("This is private")), 2)
# Poison message trace because super has no 'receiveMsg_ShortMsg'
>>>
```

The last step in the above example timed out (returning `None`) because there is no base class with an explicity `receiveMsg_ShortMsg()` method. Instead, the current method should return `ActorTypeDispatcher.SUPER` to instruct the `ActorTypeDispatcher` to continue the normal search,

```
class SubTyper4(Typer):
    def receiveMsg_ShortMsg(self, message, sender):
        if "private" in message.report:
            return self.SUPER
        else:
            self.send(sender, "Got a public short message")
```

```
>>> asys = ActorSystem()
>>> st = asys.createActor(SubTyper4)
>>> print(asys.ask(st, ShortMsg("This is public"), 2))
Got a public short message
>>> print(asys.ask(st, ShortMsg("This is private"), 2))
Got a message
>>>
```

6 ActorSystem API

The ActorSystem is created or connected-to by instantiating the ActorSystem object. External applications use the ActorSystem API to interact with Actors running within that system.

The ActorSystem API is made available by importing the `thespian.actors` module:

```
import thespian.actors
```

6.1 Exceptions

All exceptions generated by the ActorSystem itself are based on the `ActorSystemException` base class.

Exceptions which are generated as a result of unexpected failures within calls to the ActorSystem are based on the `ActorSystemFailure` base class. It is not expected that these are caused by an application error or that they can be retried and/or fixed by the application to expect a successful result.

The following shows the heirarchy of defined Thespian exceptions:

- `ActorSystemException`
  - `InvalidActorAddress`
  - `NoCompatibleSystemForActor`
  - `ActorSystemFailure`
    - `ActorSystemStartupFailure`
    - `ActorSystemRequestTimeout`
  - `InvalidActorSourceHash`
  - `InvalidActorSpecification`

6.2 ActorSystem

```
actorSys = ActorSystem(systemBase = None,
                       capabilities = None,
                       logDefs = None,
                       transientUnique = False)
```

The `systemBase` argument should specify which ActorSystem implementation base should be used for this ActorSystem, as selected from those systems describe in the ActorSystem Implementations section. If `systemBase` is None, this call will check to see if there was a previous call to ActorSystem in the current process and if so, re-use the `systemBase` from the previous call. If there is no previous call, the default system base is the `simpleSystemBase` (see simpleSystemBase).

The `capabilities` argument should be a dictionary of capability keys and values as describe in the ActorSystem Capabilities section. These capabilities form the initial set of capabilities for the ActorSystem if it is started; the capabilities are ignored if an ActorSystem is already running.

The `logDefs` argument is used to specify a logging configuration dictionary (in standard logdict format). If not specified, a default logging configuration is usually supplied. If specified as `False`, then no logging configuration is supplied; this latter is useful in situations where another component is attempting to establish a logging configuration (e.g. nosetest logcapture). As described in the Logging section, the Convention Leader will receive forwarding of log messages at Warning level or higher, providing a centralized logging capability.

Normally the created ActorSystem becomes a process-wide (and possibly system-wide) singleton instance. The `transientUnique` argument may be set to true to get a new, un-registered ActorSystem. Note that typical Python classes provide a unique instantiation on each call (i.e. the result provided here if `transientUnique` is `True`) but more typical Thespian functionality is achieved by the global singleton behavior, so that is the default and the `transientUnique` must be explicitly specified for non-singleton creations.

6.3 ActorSystem.shutdown

```
actorSys.shutdown()
```

The `shutdown()` ActorSystem method is used to terminate an Actor System and all Actors running in that system. If issued to a ActorSystem that is part of a multi-system Convention that ActorSystem is shutdown and the other Convention members are notified (but they continue to exist).

As described previously, the ActorSystem is a process-global singleton that may be a system-wide singleton, depending on the system base used (see ActorSystem Implementations for details). The `shutdown()` method is the proper way to stop those process-wide or system-wide ActorSystems when they are no longer needed. The decision of when to do this is left to the user; in some situations the ActorSystem should be a long-running service that matches the lifetime of the system itself.

If the ActorSystem was started with `transientUnique = True`, the `shutdown()` should still be used to properly stop the current ActorSystem, but any global ActorSystem registration will be unaffected by stopping the transient unique ActorSystem.

6.4 ActorSystem.createActor

```
actorAddr = actorSys.createActor(actorClass,
                                 targetActorRequirements = None,
                                 globalName = None,
                                 sourceHash = None)
```

The `createActor()` method is used by external applications to request the creation of an Actor in the ActorSystem environment. This call is very similar to the createActor Actor API call except that this version creates "Top-Level" Actors and will block until the Actor is created and throw an exception on failures.

The `actorClass` argument can be specified either as a class object or as a module-qualified string identifying a class object (e.g. ~"foo.bar.BarActor"~ will search for `class BarActor` in the `bar.py` in the `foo` directory).

The `targetActorRequirements` argument is a value that will be passed to the actorSystemCapabilityCheck to use for validating whether the Actor can be started within the current ActorSystem environment (see ActorSystem Capabilities). The value specified for this argument can be anything the target Actor's `actorSystemCapabilityCheck()` method can understand, although typically it is a Python dictionary.

The `globalName` argument, if specified, should be a string specifying the "name" of the Actor within the ActorSystem. As describe in Named Actors, this name allows the Actor to be uniquely identified and referenced in a manner additional to the ActorAddress of the actor.

The `sourceHash` argument, if specified, indicates a source file which should be prepended to the import path when attempting to load the `actorClass` source and start the Actor.

- The source file must previously have been loaded by the loadActorSource operation.
- If not specified, then the `actorClass` is expected to be found on the standard path. If the `sourceHash` value does not match any loaded sources then an `InvalidActorSourceHash` exception will be thrown.
- If the `globalName` argument is already specified and an Actor is running under that name, this argument is ignored, even if the running Actor did not come from the specified source file; otherwise the Actor started and assigned the global name.
- The specified loaded source file is merely prepended to the search list. If the loaded source file does not contain source for the specified `actorClass` but the standard path environment for the running Thespian ActorSystem **does** contain source for that `actorClass`, then the latter will be used to instantiate the new Actor.
- The source specified by the hash must have been loaded into the current Actor System, or previously have been obtained from a remote Actor System; this operation will **not** cause a query of remote actor systems to locate the source if the Actor cannot be found locally (the behavior of a `createActor()` call made by an Actor itself may be different).

This method may throw the following exceptions:

- `NoCompatibleSystemForActor` if it is unable to find an ActorSystem whose capabilities match the Actor's requirements.
- `InvalidActorSourceHash` if a source hash is specified that does not match any currently loaded source.

6.5 tell

Tell is used to inject a message into the Actor system (targeting a specific Actor) without waiting for any response message.

```
actorSys.tell(targetAddr, message)
```

The `targetAddr` must be an Actor Address known to the current application (global Actors are useful targets in this regard).

The `message` may be anything that can be sent to a remote process (i.e. pickled).

The `tell()` operation does not await a response, but it may block until the send is completed.

6.6 ask

Ask is used to send a message to an Actor (injecting it into the Actor system) and wait for a response message.

```
responseMessage = actorSys.ask(targetAddr, message[, timeout])
```

As with the `tell()` operation, the target address must be a valid Actor Address and the `message` can be anything that can be sent.

The "response message" is any message received by the local endpoint. The local endpoint looks like a normal Actor with an ActorAddress to the rest of the system. **Any** Actor sending a message to this address will cause the `ask()` operation to complete with that message.

If the `timeout` field specifies a non-None timeout value then the `ask()` will only block for the specified timeout period, returning a None value if the timeout has occurred. The recommended manner of specifying a timeout period is as an instance of the `datetime.timedelta` class, although an integer or floating point value will be accepted as a specification of a number of seconds.

6.6.1 Gotchas

- The response may come from a previous `tell()` (or `ask()` if that ask caused the Actor to send multiple messages to the requestor, not the message sent as part of this `ask()`.
- Each `ask()` call terminates with a single response; if Actors have sent multiple messages to the `ask()` endpoint, the additional messages may either be delivered on subsequent `ask()` calls, or discarded as failed message sends if this endpoint does not issue an `ask()` in a reasonable time period.

These concerns can obviously make using `ask()` tricky if there are `tell()` calls that cause responses or multiple responses to an ask; the application must be prepared to use techniques like no-response `asks()` with timeouts and message identifiers to

6.7 listen

Listen is used to wait for a message.

```
responseMessage = actorSys.listen([timeout])
```

The received message is any message received by the local endpoint. The local endpoint looks like a normal Actor with an ActorAddress to the rest of the system. **Any** Actor sending a message to this address will cause the `listen()` operation to complete with that message.

If the `timeout` field specifies a non-None timeout value then the `listen()` will only block for the specified timeout period, returning a None value if the timeout has occurred. The recommended manner of specifying a timeout period is as an instance of the `datetime.timedelta` class, although an integer or floating point value will be accepted as a specification of a number of seconds.

6.8 updateCapability

The `updateCapability()` method is used update the capabilities of the ActorSystem. This is the external interface to updating capabilities; Actors can issue capability updates as well.

```
actorSys.updateCapability(capabilityName, capabilityValue=None)
```

If the capability value is specified and is not None, the specified capability already exists, its value updated, otherwise it is created with the specified value.

If the capability value is not specified or is None, the specified capability is removed from the ActorSystem if it exists.

If the capabilities of the ActorSystem are modified by this method (i.e. the capability value is not already set as requested) then all Actors within that ActorSystem are re-validated by calling their actorSystemCapabilityCheck static method and sending them an ActorExitRequest if the capability check call returns false. _This could result in killing the Actor that initiated the capability exchange, even if new capabilities are added._ Actors may be recreated as desired; the new Actors will validate against the new set of capabilities.

The current set of ActorSystem capabilities can be obtained by issuing a Thespian_StatusReq to the ActorSystem.

6.9 loadActorSource

```
sourceHash = actorSys.loadActorSource(fileref)
```

The `loadActorSource()` method is used to load a (possibly encrypted) zipfile containing Python source code in standard Python zipimport format (via PEP302[1] methodologies). The return value is an internally-generated hash value identifying that loaded source zipfile that can be used in subsequent createActor calls to instantiate Actors found in that sourcefile.

There must be a valid Source Authority registered (via the registerSourceAuthority method) to validate the loaded source; by default this method does nothing if no Source Authority has been loaded. See Security Considerations for more information.

Although a plaintext zipfile may be loaded, it is highly recommended that production environments encrypt the zipFile using some sort of encryption methodology. The reasons for this are discussed in the Security Considerations section below; when an encrypted zipfile is loaded it is first decrypted and/or authorized as described therein.

The `fileref` argument can be a string specifying an input file path or it can be a file-like object. If the `fileref` is invalid or specifies a corrupted source file, then the returned sourceHash it is not added to the list of available sources, but there is no other feedback (excepting perhaps the `/tmp/Thespian.log` logfile).

6.9.1 Source Loading Issues

Although the `loadActorSource()` functionality works quite well, there are a few scenarios that can cause difficulties:

1. Loaded sources containing or relying on object libraries. The `loadActorSource()` functionality affects the Python module lookup, but it does not affect object file lookups that would need to be performed for native object libraries. In addition, object libraries are specific to their build environment and may not work in all

target environments. If the loaded source simply **refers** to an externally available library (e.g. PyOpenSSL python package refers to `/usr/lib/libssl.so`) then this may work if the proper object library has been installed on the target system by other means (i.e. not via the `loadActorSource()` call.

2. Sources containing other PEP302 path importers may not work correctly when used in conjuction with the `loadActorSource()` PEP302 importer. As an example, the `loadActorSource()` importer prefixes loaded modules with the Source Hash associated with those modules to ensure uniqueness. This is not always compatible with other PEP302 importers.

   (a) The `six` package (providing Python2/Python3 compatibility) uses a PEP302 importer to manage moved packages. This functionality of the `six` package is broken by the `loadActorSource()` Source Hash prefixing. To avoid this `loadActorSource()` processing handles `six` as a special case and *does not* prefix `six` with any Source Hash.

   The assumption is that `six` is a mature and unchanging package and a global version is acceptable for all loaded sources (and that a working `six` importer is preferrable to a non-working importer).

3. The `importlib` package has a subtle flaw that is not compatible with the Source Hash prefixing performed by `loadActorSource()`. To work around this problem Thespian provides an updated version of `importlib`; use " `import thespian.importlib as importlib` " instead of just " `import importlib` " in Actor sources that will be loaded via `loadActorSource()`.

4. Loaded sources should expect that `__file__` or other internals can be set to None.

5. It is not possible to send a pickled message between sources, even if that message is imported from the same file/module in both loaded sources. This is because each loaded source (and all of its top level symbols) are internally prefixed with the hash of the source they are contained in; this helps preserve independence between loaded source modules and prevents interference between them, but it means that the pickled object will have a different source hash on the target side than on the sender side. The object should be encoded in a more conventional format (e.g. JSON).

6.9.2 Security Considerations

When `loadActorSource()` is not used, the source for all instantiated Actors must come from the existing Python import path in the context of the Thespian ActorSystem. In this configuration, it is the System Administrator's responsibility to provide reasonable security and protection against code injection attacks (e.g. by using a virtualenv in a protected directory environment).

In order to prevent code injection attacks from being used with `loadActorSource()` techniques, the ActorSystem must be able to validate the following for each set of code loaded:

1. The source file has not been tampered with.
2. The source file is acceptable to run in this ActorSystem.

To achieve this protection, an Actor can register itself with the system to handle authorization and/or description of `loadActorSource()` inputs. This Actor is referred to as the Source Authority Actor. Any input subsequently provided to `loadActorSource()` is first passed to this Source Authority Actor. The Source Authority Actor can perform any validation and/or decryption of the input that it would like to and then sends back either an error or the authorized source in a form that can be utilized by the local ActorSystem.

There can be only one Source Authority Actor registered with an Actor System at any one time. Any Actor can register itself as the new Source Authority; it is assumed that the previous authorization of that Actor validated that it is allowed to run in the system and therefore assume Source Authority responsibilities. Note that in highly paranoid environments, the initial Source Authority can be used to authorize the next Source Authority, and this process can be repeated as indicated by the level of paranoia to further obfuscate the manner in which the Source Authority is established.

By default, at Actor System startup time, there is no Source Authority. When there is no Source Authority, any `loadActorSource()` input is ignored. This ensures that all Thespian systems are secure by default. For debugging and simple local applications this may not be convenient; in these situations, a Source Authority similar to the following may be used to automatically accept and enable all loaded sources:

```
from thespian.actors import *
class SimpleSourceAuthority(ActorTypeDispatcher):
    def receiveMsg_str(self, msg, sender):
        self.registerSourceAuthority()
    def receiveMsg_ValidateSource(self, msg, sender):
        self.send(sender, ValidatedSource(msg.sourceHash, msg.sourceData))
```

Note that it is possible to disable the `loadActorSource()` functionality entirely by registering an Actor as the Source Authority that will reject all loaded sources.

1. Multi-System Source Authorization

   The Source Authority registration is unique to an Actor System. Different Actor Systems in a Multiple Systems configuration can each have a separate Source Authority that may perform different authorization techniques. However, as described in Actor Code Distribution, Actor Systems joined together in a Convention can exchange sources on demand to satisfy Actor creation requests. sources exchanged between Actor Systems in this manner are not subject to further **validation** after the initial load on the original system (although the local ActorSystem can choose the level of sharing it wishes to perform; see the **AllowRemoteActorSources** capability setting in the Common Capabilities section).

   This functionality allows for maximum flexibility in handling different deployment environments:

   - In an environment where the Convention Leader ActorSystem is the centralized command-and-control system and sources should only be loaded on that system, the other ActorSystems can be initialized with a Source Authority that rejects all `loadActorSource()` attempts and therefore can run only sources provdied by the Convention Leader.
   - In an environment where all ActorSystems are trusted equally and new Actor source can be loaded via any system, they can all utilize the same Source Authority as loaded into each Actor system at the time it is started.
   - In a loose confederation of trusting ActorSystems, each ActorSystem can load its own Source Authority to control sources loaded via that system, while still sharing sources loaded on any system.

   It is important to note that in all configurations, different loaded sources are essentially independent, regardless of the method by which they are loaded and validated. The only way for one source load to access code in another source load is by issuing a `createActor()` request using the known name of an Actor in the other source load, or by being passed the ActorAddress of an already running Actor in the other source load via independent means.

6.10 unloadActorSource

```
actorSys.unloadActorSource(sourceHash)
```

The `unloadActorSource()` method is used to unload a source zipfile previously loaded by the loadActorSource operation.

This will not affect (i.e. stop) any remaining Actors running instances from that source, but it will prevent the creation of any new Actors from that source[2].

This effect of this call on running Actors' ability to access the unloaded source via imports or subseqeuent Actor creation is indeterminate: in some system bases this would fail, whereas in other bases this would succeed.

The `sourceHash` argument should specify the return value from a previous `loadActorSource()` call; if there is no source loaded with that sourceHash this request does nothing silently.

7 ActorSystem Messages

The following Messages can be delivered to Actors by the ActorSystem as a result of events within the ActorSystem itself. All of these messages inherit from the ActorSystemMessage.

In addition, the PoisonMessage, Thespian_SystemStatus, and Thespian_ActorStatus messages may be delivered to external code (as a response to an `ActorSystem().tell()` or `ActorSystem().ask()` call). All other ActorSystemMessage instances are filtered and not returned to an `ask()` or `tell()` call.

7.1 PoisonMessage

The `PoisonMessage` object is delivered to an Actor or to external code when message sent to an Actor has caused the target Actor to fail. The `PoisonMessage` is a wrapper around the original message that caused the failure. The originating sender receives this poison message indication to allow it to perform any desired cleanup or alternative work based on the target Actor failure (see PoisonMessage Returns).

7.1.1 Attributes

- `.poisonMessage` is the original message causing the target Actor failures.

[2] Note that this can result in behavioral differences between in-process and multi-process ActorSystems: unloaded sources are still present in still-existing multi-process Actors and so import statements and other references will still succeed in those Actors even after the source has been unloaded. In general it is recommended that all Actors running within a loaded source have exited before the source is unloaded, so this behavioral difference will remain unaddressed.

7.2 WakeupMessage

The `WakeupMessage` is delivered to the Actor by the ActorSystem as a result of a previous call to the Actor's `.wakeupAfter()` method call (see Timer Messages).

7.2.1 Attributes

- `.delayPeriod` which is the python `datetime.timedelta` value of the delay period that has expired.

7.3 WatchMessage

The `WatchMessage` is delivered to the Actor by the ActorSystem when one or more file descriptors has available data. The WatchMessage specifies which file numbers have data vailable.

This functionality is not available from all ActorSystem implementations. See Watching File Descriptors for more information.

7.3.1 Attributes

- `.ready` specifies a list of file numbers for which data is available. This will be a subset of the original set of file numbers returned from the Actor's `receiveMessage()` method in the 5.2.1 return value.

7.4 ActorExitRequest

The `ActorExitRequest` object is sent to any Actor to request that Actor to exit. The Actor's `receiveMessage()` is invoked with the `ActorExitRequest` object to allow the Actor to do any internal cleanup; the cleanup must be completed because when the Actor's `receiveMessage()` method exits from handling the `ActorExitRequest` object, the Actor is killed with no further functioning.

The `ActorExitRequest` may be originated by the ActorSystem itself (e.g. a ActorSystem shutdown time) or it may be sent by any other Actor within the system.

7.4.1 Attributes

- `.isRecursive` indicates that this ActorExitRequest will automatically be propagated to all children of the current Actor following its processing by this Actor.
- `.notRecursive()` updates this ActorExitRequest to disable recursive propagation to all child Actors.

7.5 ChildActorExited

The `ChildActorExited` object is delivered to the Parent Actor of an Actor when that Actor has exited. This is delivered regardless of whether the exit was due to the receipt of an ActorExitRequest message or if the Actor was killed by other means.

The Parent of Named Actors is the ActorSystem itself; no other Actor will receive a `ChildActorExited` message when a Named Actor exits.

Actors which were created by the external system via the ActorSystem interface will have no Parent; their exit is unremarked.

7.5.1 Attributes

- `.childAddress` is the address of the child Actor that exited. Note that this `.childAddress` may be different than the `sender` argument passed to the current Actor's `.receiveMessage()` method.

7.6 DeadEnvelope

The `DeadEnvelope` object is delivered to the Dead Letter handler as described in Dead Letter Handling. The `DeadEnvelope` is a wrapper around the original message that could not be delivered to the target Actor because the target is no longer running.

7.6.1 Attributes

- `.deadMessage` – the original, undeliverable message
- `.deadAddress` – the address to which the message could not be delivered

7.7 ActorSystemConventionUpdate

The `ActorSystemConventionUpdate` object is delivered to an Actor that has registered to be notified on changes in ActorSystem convention membership (as described in Other Actor Systems). This message is generated by the ActorSystem itself.

7.7.1 Attributes

- `.remoteAdminAddress` – Address of the Admin for the remote ActorSystem.
- `.remoteCapabilities` – The current capabilities of the remote ActorSystem.
- `.remoteAdded` – True if the ActorSystem is registering, False if it is actively de-registering or has been automatically de-registered for failing to checkin.

7.8 ValidateSource

The `ValidateSource` object is delivered to the registered Source Authority. The contents are the source file provided via the loadActorSource call to the ActorSystem. The Actor receiving this message should decrypt and validate the source to ensure that the source is authorized to run in the context of the current ActorSystem.

If the specified source is not authorized to run in the current ActorSystem, the Source Authority simply discards this message and takes no further action.

If the specified source is valid for running in the current ActorSystem, the Source Authority should return a zipfile containing **compiled sources only** to the sender in a ValidatedSource message.

It is important to note that the sources provided to the `loadActorSource()` call are not actually available for use in `createActor()` calls until the Source Authority has responded with the ValidatedSource message. If it is expected that the Source Authority will experience delays in validating the source, or that the attempts to use the loaded source will immediately follow the `loadActorSource()` call, the code calling the latter should implement a delay or an explicit validation of the results of the load via the Thespian_StatusReq operation.

7.8.1 Attributes

- `.sourceHash` – the hash associated with this loaded source.
- `.sourceData` – the input data (file contents) provided to the loadActorSource call to the ActorSystem.

7.9 ValidatedSource

This message is not sent by the ActorSystem to an Actor, but is instead sent by the Source Authority Actor back to the system as the response to a ValidateSource message. The data associated with this response is a zipfile in zipimport format providing the **compiled sources only** that were extracted from the input data sent via the `ValidateSource` message. By sending this message back to the sender, the Source Authority Actor is indicating that the associated contents are valid for running within the current ActorSystem environment (and any other Actor Systems that are part of the Convention).

Only compiled objects are returned (with `.pyc` or `.pyo` extensions) in the returned zipimport file to further preserve security: an attacker with visibility into the memory of the ActorSystem would need to locate and de-compile the body of the zipfile instead of being granted access directly to the decrypted original sources.

7.9.1 Attributes

- `.sourceHash` – the hash associated with the loaded source as provided in the `ValidateSource` input message.
- `.sourceZip` – the zipimport-format decrypted and validated compiled form of the originally provided source.

7.10 Thespian_StatusReq

The `Thespian_StatusReq` object can be sent to any Actor (or to the ActorSystem...e.g. the Admin if the ActorSystem has one) to request Thespian-related status information. The status information is information from within Thespian itself; the Actor does not receive or provide handling of this message itself.

The response to the `Thespian_StatusReq` is either a Thespian_SystemStatus or a Thespian_ActorStatus message, depending on whether the `Thespian_StatusReq` was sent to an Actor or the ActorSystem.

7.10.1 Attributes

The `Thespian_StatusReq` object has no attributes.

7.11 Thespian_SystemStatus

The `Thespian_SystemStatus` object is returned by the ActorSystem with status information about that ActorSystem. The information in this message is informational only and subject to change: relying on specific fields or values in this message is not recommended.

7.12 Thespian_ActorStatus

The `Thespian_ActorStatus` object is returned by the ActorSystem with status information about that ActorSystem. The information in this message is informational only and subject to change: relying on specific fields or values in this message is not recommended.

8 ActorSystem Implementations

One of the convenient aspects of an Actor architecture is that the Actors themselves are insulated from and agnostic to any particular transport type: the Actor System provides the message delivery and underlying Actor support functionality.

- The implementation of the Actor System can be changed or redesigned without the Actors themselves needing to change.
- Different implementations can be chosen for different circumstances to meet the needs of that particular circumstance.

The Actors themselves interact with the ActorSystem via the normal `.send()`, `.createActor()`, `.receiveMessage()` methods defined for the Actor.

The external environment can interact with the Actors by making requests via the ActorSystem object itself. In addition, the Actor System must be initially created to provide an environment for all Actors that are subsequently run within that Actor System; this creation is the responsibility of code in this external environment. When external code calls the `ActorSystem()` constructor, an Actor System is started if one is not already running.

An argument may be passed to the ActorSystem constructor to specify the systemBase (a.k.a Actor System implementation) that should be used for starting the Actor System if one is not already running; if an Actor System is already running, this argument is ignored. If no argument is specified and no Actor System is running, the default simpleSystemBase Actor System will be started.

The following table provides a summary of the different bases; more details are available in each section:

Base	Description
simpleSystemBase	No parallelism. Primarily useful for unit testing. Default base.
multiprocQueueBase	Multiple processses using Python Queue for communications. Cannot support conventions.
multiprocTCPBase	Multiprocessing using TCP communications. Use this base if your are unsure of which base to choose.
multiprocUDPBase	Multiprocessing using UDP communications. Lighter-weight than TCP version, but can drop packets.

8.1 Common Capabilities

As described in ActorSystem Capabilities each ActorSystem has a set of capabilities that describe that ActorSystem and which can be audited by the Actor's actorSystemCapabilityCheck method to determine if the Actor is compatible with the ActorSystem. Many capabilities can be set when the ActorSystem is started (see ActorSystem), or updated at run-time (see updateCapability for either the Actor or the ActorSystem API); those marked *read-only* below may only be viewed, but not set or changed when the ActorSystem is started.

Each ActorSystem may specify capabilities unique to that ActorSystem and the application can add capabilities to that ActorSystem; in addition, the following common capabilities are defined for all ActorSystems:

Python Version *read-only* This is set to the tuple value of the Python version under which the ActorSystem is running (this is the same value supplied by `sys.version_info`). Any Actors wishing to enforce any version restrictions use this capability to do so.

Thespian Generation *read-only* This is the Thespian API functionality specifier as a tuple of two values: `(generation, enhancement)`. The first value is the `generation` and indicates a major functionality level (which is not necessarily backwards-compatible with the previous functionality level). The second number is the `enhancement` value and is incremented when backwards-compatible functional enhancements have been added within the current `generation`. The `generation` value is monotonically increasing, whereas the `enhancement` value monotonically increases within a `generation` but resets to zero when the generation changes. The Thespian Release Notes should be consulted to determine what features are supported in what generations.

This value is also available to current code in the `thespian.api` import as the `ThespianGeneration` value; if this local value is different than the ActorSystem provides in the capabilities

Thespian Version *read-only* This is the identifier for the version of Thespian running in the current environment. This is a single numeric value where later releases will have a higher (but not necessarily successor) value.

Thespian ActorSystem Name *read-only* This is the name of the running ActorSystem implementation. It is encouraged that Actors are not written to be unique to any particular implementation, but this information is present to allow ActorSystem-specific capability verification.

Thespian ActorSystem Version *read-only* This is the ActorSystem version as a single numeric value (similar to the `Thespian Version` capability. This value may be incremented separately from the `Thespian Version` to indicate an update in the underlying ActorSystem implementation. The value of a specific ActorSystem will increment, but different ActorSystems have different version namespaces and switching from one to another does not guarantee that the ActorSystem version will increment.

AllowRemoteActorSources This capability specifies whether or not this ActorSystem will accept sources loaded via remote Actor Systems as described in the Actor Code Distribution section. Valid values for this capability are:

Yes Any Actor Source validated by a Source Authority on a remote system can be run on this system as well (this is the default).

No No Actor Sources from remote systems will be accepted locally.

LeaderOnly Only Actor Sources provided by the Convention Leader will be accepted locally.

Any unrecognized value will be treated as **No** and will disallow sources loaded on remote systems to be used in the current Actor System. If this capability is not specified, the default is **Yes** which will accept sources loaded on any of the remote Actor Systems that are part of the Convention.

8.2 simpleSystemBase

The simpleSystemBase implementation is primarily designed for Unit Testing and other very simplistic Actor environments:

- All Actors run synchronously in the context of the current process thread.
- It is possible for an Actor to modify global state referenced by other Actors (as a matter of principal, accessing global state is an anti-pattern for the Actor Model).
- It is possible for an Actor to modify the caller's version of the message (see `Message Mutability`).
- The actorSystemCapabilityCheck is not called for any Actors: all actors are created in the current ActorSystem regardless of their capability requirements.
- No support for Multiple Systems (e.g. Conventions)

Specifically, whenever an ActorSystem `.tell()` or `.ask()` is called, the message is passed to the target Actor and any subsequent actorCreate or message sends performed by that Actor are run in sequence, etc. recursively. When the `.tell()` or `.ask()` completes back to the caller, most messages have been propagated through the system and it has reached equilibrium.

There is one exception to the equilibrium state: pending wakeupAfter wakeups. These wakups may still be pending when the `.tell()` or `.ask()` returns, and will not be delivered in the background subsequent to that return. If the wakeup time period expires during a future call to `.tell()` or `.ask()` then the `WakeupMessage` will be delivered at that point. Wakeup periods that expire in the interim are not acted upon until a future `.tell()` or `.ask()`, and if no future calls of this type are made then those wakeups are never delivered.

The simpleSystemBase is commonly used for unit testing configurations; as such, specifying the `logDefs` constructor argument as `False` helps prevent this system base from interfering with any log capturing that is performed by the unit testing framework (e.g. nosetest logcapture).

The simpleSystemBase uses the following ActorSystem Capabilities:

Thespian ActorSystem Name *read-only* "simpleSystemBase"

8.3 multiprocQueueBase

The multiprocQueueBase runs each Actor in its own separate process for a truly asynchronous system. The default Actor communication method is by utilizing multiprocess Queue objects. The Actors are constrained to the current system, which is unique to the starting process. There is no inter-system communications possible, nor sharing of the Actor System with processes that are siblings of the starting process (i.e. not started by the ActorSystem itself).

The multiprocQueueBase System Base is used between all processes that were created from the original creation of the SystemBase, but a new SystemBase is created by each initiating process and the Queues are unique between the different SystemBase elements. The lifetime of the Actor System is limited to the lifetime of the process that created it.

The multiprocQueueBase uses Python's multiprocess Queue objects, but due to the fact that these Queues can only be passed by direct process inheritance and not via pickling, this system base can be somewhat inefficent due to the manner in which this implementation must route messages through a chain of actor processes from source to destination.

The multiprocQueueBase can only be used for communications on the current system and not for inter-system communications. The multiprocQueueBase does not support the use of multiple ActorSystems in a Convention as described in Multiple Systems.

The multiprocQueueBase uses the following ActorSystem Capabilities:

Thespian ActorSystem Name *read-only* "multiprocQueueBase"

Admin Address *read-only* the address for the Admin queue. This is an arbitrary string value; the default is 'ThespianQ'.

Process Startup Method *optional* specifies the multiprocessing process startup method (see `multiprocessing.get_context()`). Supported values are "fork" and "spawn". The "spawn" method is generally slower because it creates each new process from scratch, but it provides better independence and isolation. The "fork" method is faster but can inherit memory and other resources from the parent, and it is only available under Unix. Note that the other multi-process bases support the multiprocessing "forkserver" method, but this multiprocQueueBase does not support the "forkserver" method.

8.4 multiprocTCPBase

The multiprocTCPBase runs each Actor in its own separate process for a truly asynchronous system. The default Actor communication method is by utilizing TCP socket connections.

The multiprocTCP SystemBase is shared between all processes that utilize the same Administrator coordinates, and can be used for inter-system communications. The lifetime of the Actor System exceeds that of the process that started it and persists until an explicit shutdown.

The multiprocTCPBase can be used for Actors on the same system or on other systems accessible via TCP/IPv4.

The multiprocTCPBase supports forwarding of logging messages (warning and above) to the Convention Leader if used in a multi-system configuration.

The multiprocTCPBase uses the following ActorSystem Capabilities:

Thespian ActorSystem Name *read-only* "multiprocTCPBase"

Admin Port which specifies the TCP port number upon which the ActorSystem will listen for new communications. Actors and the external systems do not need to access that port specifically: it specifies which port the ActorSystem uses internally for coordination of operations.

If a multiprocTCPBase ActorSystem is already listening at that port, then the existing system will be utilized; otherwise a new multiprocTCPBase ActorSystem will be started up.

If not specified, the default Admin Port of 1900 is used.

Convention Address.IPv4 the IPv4 address of the convention leader's Admin. This should be specified either as a tuple of *(hostname, portnum)* or as a string of the form "hostname:portnum". The hostname may be a DNS name or a dotted quad IPv4 address (specified as a string) and references the host on which the Convention Leader Admin is to be found. The portnum is the **Admin Port** upon which that Admin listens; if not specified (no colon is found) then the port num defaults to the **Admin Port** setting.

Admin Routing if this capability is present and has a true value, this indicates that all Actors in remote Actor Systems must send all messages to local Actors through the Admin. This is commonly used where the Actor System is running on a host node that has a firewall that only allows the Admin Port to have network ingress permissions.

Note that this capability has no effect on the way in which the Actors themselves are implemented; it only changes the way that the Actor System routes messages.

Outbound Only if this capability is present and has a true value then it means that this Actor System (and all of the Actors within it) can only initiate outbound connections. Inbound connections are not supported.

This configuration may be needed for a system that is behind a firewall with very strict ingress rules but looser egress rules.

Specifying this capability as True will implicitly force "Admin Routing" to be true as well, regardless of the user setting. This is because it is impractical for this system to maintain outbound connections to all possible remote Actors, so it will maintain a persistent connection to other Admins only and forward packets via them using the "Admin Routing" functionality.

In addition, this system will not be able to join in conventions with other systems unless the other systems are declared via the `preRegisterRemoteSystem()` call, since they cannot initiate an inbound registration to this system.

Remote systems may encounter periodic delays in message forwarding messages to an Outbound Only system because they must await a connection establishment from that system (which may not occur until the next Convention Registration time period has elapsed). (This mode also requires socket re-use by the TCP transport, which is the normal operational mode).

Thespian Watch Supported *read-only* If True, then an Actor may return the `ThespianWatch` object from its `receiveMessage()` method and be called back later when input is available on any of the numbered file descriptors passed in the `ThespianWatch` object.

Process Startup Method *optional* specifies the multiprocessing process startup method (see `multiprocessing.get_context()`). Supported values are "fork", "forkserver", and "spawn". The "spawn" method is generally slower because it creates each new process from scratch, but it provides better independence and isolation. The "fork" method is faster but can inherit memory and other resources from the parent, and it is only available under Unix. The "forkserver" performance is between the other two, but closer to the performance of the "spawn" method.

8.5 multiprocUDPBase

The multiprocUDPBase runs each Actor in its own separate process for a truly asynchronous system. The default Actor communication method is by utilizing UDP messages.

The multiprocUDP SystemBase is shared between all processes that utilize the same Administrator coordinates, and can be used for inter-system communications. The lifetime of the Actor System exceeds that of the process that started it and persists until an explicit shutdown.

As with most UDP-based exchanges, there is no guarantee that messages have been delivered. One effect of this is that it is often difficult for the ActorSystem to recognize that Actors have exited and so Dead Letter delivery is unreliable at best for this system base.

Additionally, the UDP-based ActorSystem can only exchange messages up to 64KiB in size. Larger messages will fail.

The multiprocUDPBase can be used for Actors on the same system or on other systems accessible via UDP/IP.

The multiprocUDPBase supports forwarding of logging messages (warning and above) to the Convention Leader if used in a multi-system configuration.

The multiprocUDPBase uses the following ActorSystem Capabilities:

Thespian ActorSystem Name *read-only* "multiprocUDPBase"

Admin Port which specifies the UDP port number upon which the ActorSystem will listen for new communications. Actors and the external systems do not need to access that port specifically: it specifies which port the ActorSystem uses internally for coordination of operations.

If a multiprocUDPBase ActorSystem is already listening at that port, then the existing system will be utilized; otherwise a new multiprocUDPBase ActorSystem will be started up.

If not specified, the default Admin Port of 1029 is used.

Convention Address.IPv4 the IPv4 address of the convention leader's Admin. See the description of the same capability in the multiprocTCPBase for more details.

Process Startup Method *optional* specifies the multiprocessing process startup method (see `multiprocessing.get_context()`). Supported values are "fork", "forkserver", and "spawn". The "spawn" method is generally slower because it creates each new process from scratch, but it provides better independence and isolation. The "fork" method is faster but can inherit memory and other resources from the parent, and it is only available under Unix. The "forkserver" performance is between the other two, but closer to the performance of the "spawn" method.

9 Deploying Actor-based Projects

Possible Methods for deployment:

- Create a virtualenv via os-specific packaging (e.g. RPM) of all dependencies including Thespian. This is a single, self-contained installation containing all needed elements and can be started and stopped distinctly.
- Distribute Thespian and a Source Authority via os-specific packaging to make the ActorSystem available. This establishes the base service and other elements can be deployed via the loadActorSource() operation.

The former method is a simpler method, but it means that the ActorSystem cannot be shared amongst separate applications, and that any deployment will completely shutdown the previous ActorSystem and Actors before starting the new one.

Using the latter method is slightly more complicated from a packaging complexity perspective, but it allows the ActorSystem to be shared by multiple Actor-based applications, as well as providing for seamless upgrades of each application (because the new and old sources can be running simultaneously).

9.1 Overall Security Considerations

ActorSystem Startup ActorSystem startup will inherit the permissions of the starting user. In many cases this is root to afford the actors the needed abilities to perform their operations.

ActorSystem Restart This is the process of stopping an ActorSystem and restarting a new one. There are no restrictions placed on stopping an ActorSystem because this could result in unwarranted difficulties, and the ActorSystem can already be stopped in other ways (eg. process kill, etc.). Although it is possible for an attacker to stop the running ActorSystem and restart it, the resulting ActorSystem will only be running with the permissions it inherits from that starting user, and the protections detailed below still apply. This is not an effective attack vector for the ActorSystem.

Actor Injection the use of the Source Authority (see registerSourceAuthority) and associated sourceHash values prevent the ability to inject bad actors into the ActorSystem.

Message Injection Each Actor is responsible for any validation or verification of the messages it receives.

Message Interception To protect messages from snooping, a VPN should be used or the configuration should select an ActorSystem base should be used that provides ssl-secured communications

Convention Source Injection In this scenario, another member of the ActorSystem Convention that has been compromised attempts to inject bad Actor sources into the system. This is prevented by using the **AllowRemoteActorSources** capability to prevent injection of sources from ActorSystem hosts that are subject to compromise.

It is often desireable to deploy the Convention Leader into a more protected environment than may be possible for the remote ActorSystem Convention members and to use the **AllowRemoteActorSources** capability to restrict the use of newly loaded Actor Sources to only those Sources loaded on the Convention Leader system.

Actor Hijacking e.g. sql injection attacks, buffer overrun, etc. These are the responsibility of the Actor developer, but remember the guideline: "Fail Early, Fail Often."

9.1.1 Security Scenarios

On any particular host where an ActorSystem is running, the primary focus is on protecting that ActorSystem to prevent injection of code by malicious users. It is assumed that the users do not have root access.

On systems where a user has local root access but that user is not a trusted user for the entire environment, the user's influence through the ActorSystem should be restricted to only the system they have access to. The *Convention Source Injection* protection describe above assists in this case.