



Usage

Thespian

Python Actor System

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2022 Jan 18 (#2.24)

Thespian Project

TheDoc-02

PUBLIC DOCUMENT

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1 Actor Overview

1.1 Actors

At the core, an Actor system is 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. The Actor operates solely on information passed to the Actor via a message or else generated internally by the Actor itself.

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 receiving a message will perform some sort of application-specific processing as a result.

1.2 Actor Addresses

All Actors have an Address which identifies them uniquely within the ActorSystem. The ActorSystem assigns an Address to an Actor and the Actor should treat that Address as an opaque value.

Actors will communicate with other Actors using the ActorAddress of the other actors. ActorAddress values cannot be synthesized. An Actor obtains the ActorAddress of other actors in one of two ways:

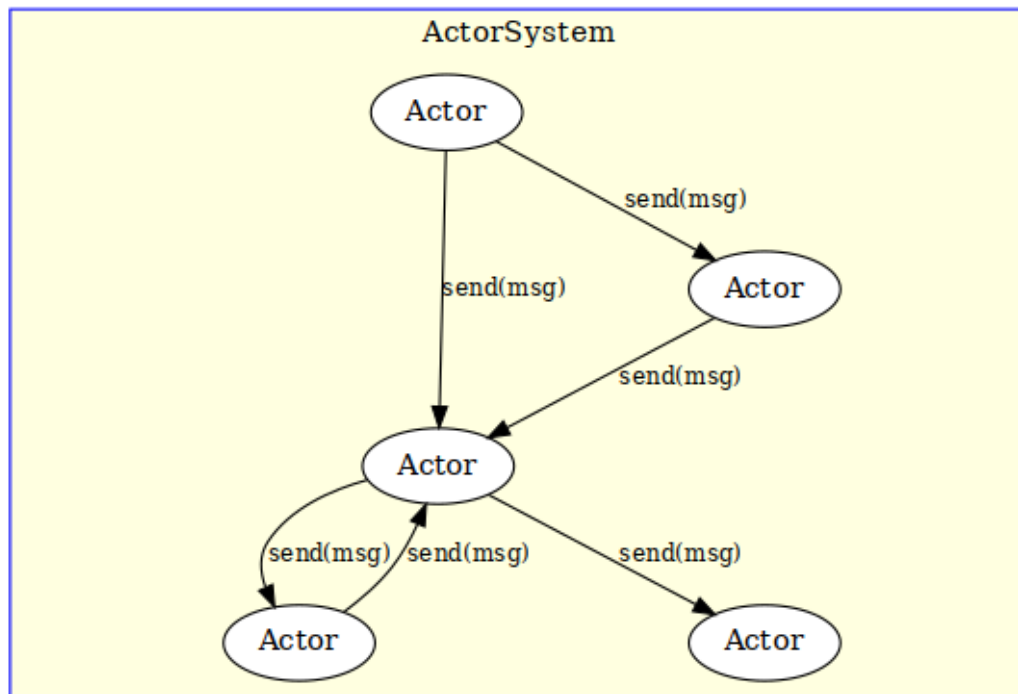
1. The return value from an Actor create request is an ActorAddress
2. Receiving an ActorAddress in a message from another Actor

The ActorSystem determines the actual value of an ActorAddress and the value 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 are multiple different types of ActorSystem implementations. Switching from one system to another can does not require 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; the Actor receives an ActorAddress as a result of creating an Actor or in a message received from 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.

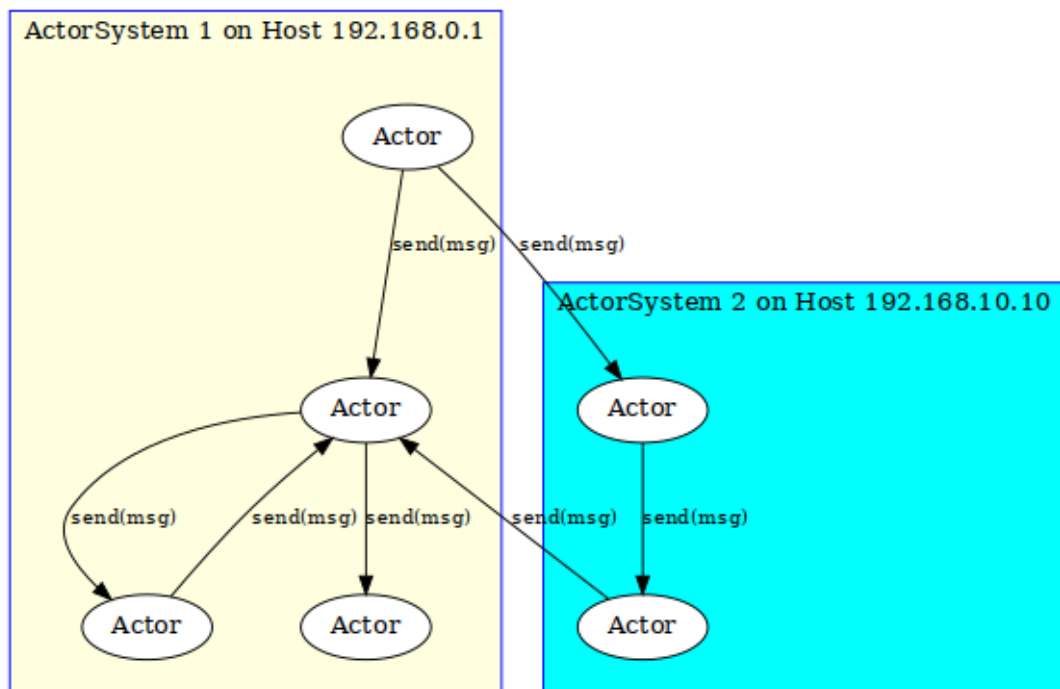
Another example is an ActorSystem that uses TCP networking to communicate between Actors v.s. a system that uses local shared-memory queue structures.

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.

Actors can be created within "remote" ActorSystems as well as the local ActorSystem. 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.



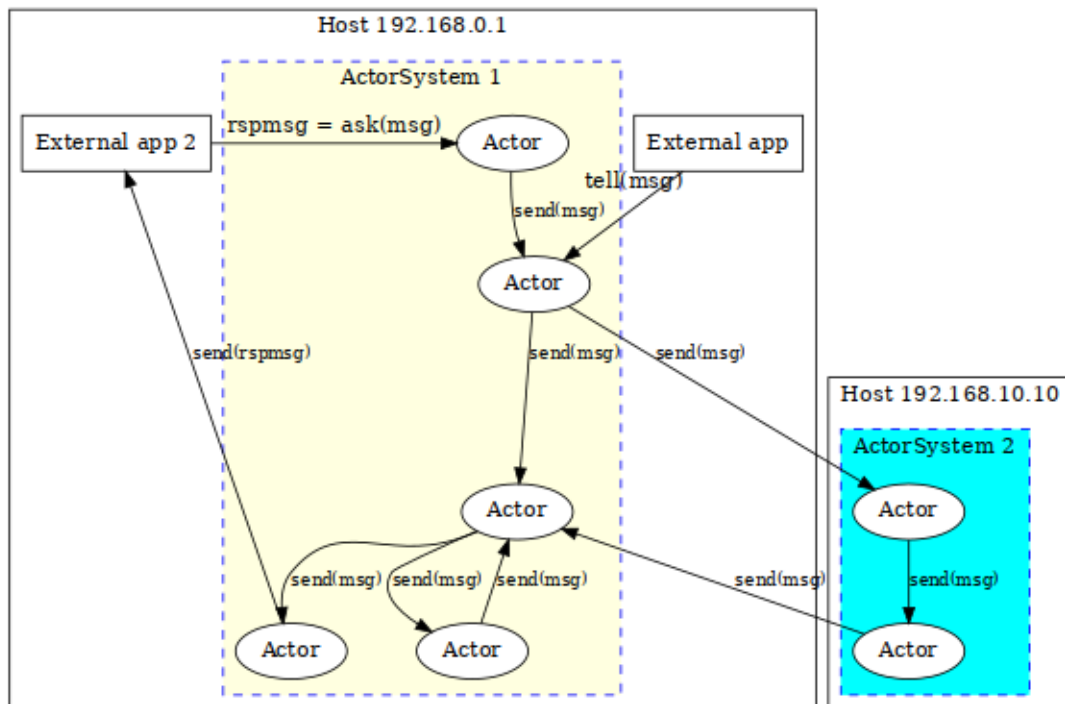
This facility allows for location independence and also provides for essentially unlimited scalability of the underlying support environment.

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. External applications use the following ActorSystem operations to communicate with Actors in that system (these operations are not intended for use by Actors themselves):

- **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 the Actor to send a response message.
- **createActor** – creates a new Actor. There is no Parent Actor for the newly created Actor; this Actor is referred to as a "top-level Actor" and it is managed by the ActorSystem itself. 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.



The ActorSystem API section has more details on the ActorSystem operations.

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, etc) are all 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 could be implemented on top of a message-bus architecture; the Actors themselves are 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 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 the ActorSystem section of this document and the known system bases are describe in the ActorSystem Implementations section.

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

2.2 Actor Lifecycle

Actors are created on demand and then persist until they receive a request 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.

The `ActorSystem.createActor` call creates a Top-Level Actor:

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

The result of the call is the `ActorAddress` associated with the Actor. The ActorSystem's `ask()` or `tell()` methods use this `ActorAddress` to communicate with the created Actor.

2.2.2 Creating an Actor

Within the ActorSystem an Actor can create another Actor by making a request to the ActorSystem. This is done by calling 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 of class `Actor` creates a new `Actor` instance and returns the `ActorAddress` associated with it. The creating `Actor` can then send messages to the new `Actor` via its own `send()` method while passing the `ActorAddress` of the new `Actor` (which is `newActor` in the example above) as the target address. The creating `Actor` becomes the Parent `Actor` of the created `Actor`.

2.2.3 Killing an Actor

Actors normally continue to exist and handle messages until they are explicitly killed. An `Actor` can be killed by sending it 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 when it returns from `.receiveMessage()`, the `ActorSystem` will kill the `Actor`.

A killed `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 `ActorSystem` notifies the Parent `Actor` when any of its child `Actors` exit. Child `Actors` are killed when the Parent dies unless the Parent indicates that the `ActorExitRequest` should not propagate to the children (see method `notRecursive()`).

Notification of exited children is done 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 by throwing an exception, the `ActorSystem` will automatically catch that exception. The message is automatically re-issued to the `Actor` to give it a second chance to handle the message. If the second attempt also throws an exception, the message is returned via a `PoisonMessage` to the caller and that `Actor` continues with the next message. 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.

If a process-based `Actor` process exits (e.g. via a signal or un-catchable exception) then the Thespian `Actor` System will (eventually) detect the exited process and deliver a `ChildActorExited` message to the parent `Actor`. It is up

to the parent Actor to determine what to do in this situation, but a common response is to simply create another instance of that exited child Actor.

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

- The ActorSystemMessage class is the base class of all ActorSystem internal messages. 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 ActorSystem will return the message that caused the failure to the sender in a PoisonMessage wrapper.
- The messages that the ActorSystem can synthesize and 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 simple actors can safely ignore any and all messages from the ActorSystem; more sophisticated Actors will handle ActorSystem messages 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 ActorSystem 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.

- The ActorSystem is limited by system execution limits. For example, ActorSystems implementing actors as separate processes may be limited by the number of processes that can be created (e.g. `$ ulimit -u` on Unix), and ActorSystems using sockets for communications may be limited by the number of file descriptors (`$ ulimit -n`), the max syn backlog (`$ sysctl net.ipv4.tcp_max_syn_backlog`), local port ranges (`$ sysctl net.ipv4.ip_local_port_range`), and various other system limits.

Thespian does not make any attempt to adjust these values, and will do its best to work within the available limits (e.g. closing idle sockets when the allowed socket limit is reached), but the user should ensure that the ActorSystem is configured properly for the expected utilization.

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 outgoing message 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 independently handled: messages for a specific target are sent in order but messages queued to different targets are sent 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 sent message is delivered, the message is redirected as described in Dead Letter Handling.

4.1.1 Message Mutability

Thespian does not automatically generate copies of sent messages, but instead 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 outgoing message is directly generated, 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, that message data **may** be modified by code in the recipient.

```

1 class ActorA(Actor):
2     def receiveMessage(self, message, sender):
3         ...
4         actorb = self.createActor(ActorB)
5         newmsg = NewMessage(foo="foo")
6         self.messages.append(newmsg)
7         self.send(actorb, newmsg)
8         ...
9         for each in self.messages:
10            assert each.foo == "foo"
11
12 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. The system Base being used and the timing of execution between the two actors determines whether or not ActorA's message will pass the asserting test. When using a multi-process system base, ActorA's version is independent because the two Actors run as separate processes and so ActorB has a separate copy of the message and does not modify the version that ActorA references, but the `simpleSystemBase` (for example) would allow this modification.

If an Actor references a message post-send, it should be aware of this potential for modification. ActorA can make a copy of the message (e.g. `self.send(actorb, copy.deepcopy(newmsg))`) to avoid this issue 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 is dead or has otherwise exited), the ActorSystem will route that message to Dead Letter handling. A `DeadEnvelope` wrapper is placed around the message to indicate this situation.

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 is not a fail-safe to prevent messages from getting lost, but it is a recommended method by which 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 the new Actor would receive those messages which would undoubtedly 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 Dead Letter Handling discards all messages sent to a non-starting Actor.

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 delivery of subsequent messages still occurs.

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`. Any Actor can use this `ActorAddress` to send a message to the created Actor.

At times, however, it may be convenient to 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 ActorSystem will remember the Actor associated with that name and all subsequent Actor creation requests with the same name will return

the originally created Actor (see the `globalName` parameter to the ActorSystem's `createActor` call or the Actor's `createActor` call).

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 to consider as offsets relative to their convenience:

1. The ActorSystem itself manages all Named Actors (similar to Top-Level Actors) 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.
3. The `globalName` is (at present time) unique only to the Actor System within which it is running. There may be multiple Actor Systems running and communicating as part of a Convention (see Other Actor Systems), but the uniqueness of the `globalName` (and corresponding Actor instance) applies only to the system that has created it. See Multi-system Global Name support for more details and recommendations.

It is recommended (but not required) that only the top-level, coordinating Actors be Named Actors and that most Actors in the system be unnamed Actors to avoid these disadvantages.

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.

To distinguish `WakeupMessage` instances that have been scheduled for different purposes, it is possible to supply a `payload` as a second parameter to `.wakeupAfter()`. The `payload` can be arbitrary but it is accrued against the actor's memory until it is delivered. Hence, it is recommended to keep the `payload` reasonably small.

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 significantly 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 queuing 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.

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.

See Actor Troupe Support for more details.

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.

An Actor System Convention is managed by one or more convention leaders, whose job is to help route actor creation and actor messages between different systems with potentially different capabilities. There is currently Beta support for having multiple convention leaders to provide a measure of fault-tolerance in case a convention leader fails or exits the convention; this support is currently in Beta status and should not be used in a production environment.

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

4.11.1 Convention Establishment

The ActorSystem implementation determines the manner in which Conventions are established and should be consulted for details and capabilities, but at the present time there are two main methods for establishing a Convention:

1. Members known the Convention Leader and upon startup register with the Convention Leader. In this mode, the Convention Leader operates passively and does not initiate or drive the Convention membership.
2. The Convention Leader is told about members and actively attempts to establish communications with those members. This is done using the `preRegisterRemoteSystem()` call. In this mode, the Convention Leader will actively connect to the remote to establish or re-establish connectivity (until the membership is cancelled, for example, with the `deRegisterRemoteSystem()` call).

This latter method is particularly suited to configurations using the "Outbound Only" connectivity mode (see `multiprocTCPBase` for example) where the Convention Leader is behind a firewall and can initiate outbound connections to members but those members cannot initiate inbound connections to the Leader.

4.11.2 Convention Administrator Communications

The communications between the Convention Leader admin process and the Convention Member admin process is handled internally by Thespian.

To prevent network overload in unexpected or erroneous circumstances, the Convention communications uses an incremental hysteresis delay on communications between the admin processes; this delay increases when there are active messages being exchanged and decreases during idle times. The overall traffic between two Convention administrators is expected to be relatively low volume, but in unusual circumstances this delay may become observable. The hysteresis delay is designed to protect the overall environment from failure scenarios; please contact the Thespian developers if this hysteresis is adversely affecting your utilization of Thespian.

4.11.3 Multi-system Global Name support

Actor creation is first attempted locally, but if the Actor's requirements do not match the local system's capabilities, other Actor Systems will be invited to create the specified Actor, one at a time. The first Actor System that can create the specified Actor will record the global name in that system; if an Actor System already has an Actor running under that global name, that will satisfy the creation attempt.

Because this global name is only recorded on a single system and the creation is on a first-found basis, it is not necessarily the case that the next attempt to call `createActor` with the same `globalName` will query the same system before another system is found that is willing to create the target actor. As a result, two `createActor()` calls with the same `globalName` value may result in two different target Actors running on two separate remote Actor Systems.

An recommended alternative approach is to create a "registrar" Actor on the Convention Leader system, using a `globalName` to ensure that the registrar instance is unique. The registrar can then register for notification of remote Actor Systems (`notifyOnSystemRegistrationChanges`) and when a new remote Actor System joins the convention, the registrar Actor can create a specific Actor on that remote system, recording the resulting address locally in the registrar. When that unique remote Actor is needed, the registrar can be consulted to obtain the target address.

4.12 Performance

The Thespian implementation is design principles are: correctness, reliability, responsiveness, and performance — in that order. In general Thespian is intended to be used in situations involving Actors that communicate relatively frequently with each other, but not necessarily with high volumes of data. While there is nothing in the Thespian implementation that prevents exchanging multi-megabyte messages between Actors, the implementation is oriented more towards low latency and responsiveness rather than high-speed streaming.

To further ensure that a Thespian Actor-based application is a good network citizen, there is automatic rate limiting applied to the exchange of messages between Actors. This rate limit is currently set to approximately 80Mib/s — slightly less than the traffic rate that would saturate a 100Mib/s Ethernet link. This is designed to protect the overall environment from runaway failure conditions in the Actor-based application; please contact Thespian development if this is adversely affecting your Actor-base application.

4.13 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 to sending log messages to the Logging actor, the Convention Manager ActorSystem also receives all log messages from any conference member that is of `WARNING` level or above. This facilitates centralized logging of significant issues across a multitude of hosts running ActorSystems.

Once the logging configuration has been specified in the `ActorSystem()` call, the normal python logging library can be used to generate logging messages; these messages will be forwarded to the Logging actor (and possibly the Convention Manager) where the actual logging will occur.

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.

The logging configuration is specified using the standard Python Logging dictionary specification (documented in <https://docs.python.org/3/library/logging.config.html>). 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.

4.13.1 Logging Level Management

When each Actor is started, the base level of messages forwarded to the Logging Actor for that started Actor is based on the **minimum** logging level specified in the logDefs dictionary (for any handlers, loggers, or root entry).

- If no logDefs dictionary is specified, the base level is 0.

- If any handler, loggers, or the root entry does not explicitly specify the logging level, the Python default level is 0, which will be the minimum logging level extracted from the logDefs configuration.
- A logging level of 0 results in **all** messages being forwarded to the Logging Actor.
- For Thespian versions 3.10.1 and before, the logDefs does not affect the logging level of each Actor and the level is effectively 1.

In implementation terms, the forwarding to the Logging Actor is implemented as a Log Handler. In Python, there may be multiple Log Handlers defined but the handler which forwards to the Logging Actor is pre-declared.

The Python Logging API is implemented via a Logger object, which provides its own filters and log-level thresholds before passing log messages to the handlers for performing the logging. Each Actor can adjust the logging level for the Logger object to modify the level at which messages are logged, but setting the Logger's log-level below the level that the Logging Actor Handler was started with has no effect: the Logger will low log-level messages to the Handler but they will fail the handler's threshold check and not be forwarded to the Logging Actor.

Note: the Python Logging API's do not allow a Handler to be retrieved from the Logging framework, so it is not possible for the Actor to modify the logging threshold level of the Handler.

4.13.2 Logging Transmit Overruns

Some libraries or python code will perform significant amounts of logging, especially at the DEBUG level, since normally these are not displayed but they can be useful when debugging problem situations.

This can, however, create an issue in Thespian if the logDefs are not specified and the Actor does not set a Logger level: all of these log messages will be forwarded to the Logging Actor. Thespian maintains an outbound message threshold; if this threshold is exceeded (e.g. by too many queued log messages), then the Actor is placed into transmit-only mode until the queue has dropped back below a lower threshold (see Message Delivery for more details). This can degrade the Actor's responsiveness due to messages that are subsequently discarded by the Logging Actor.

Prior and up to Thespian release 3.10.1, the only way to address this is for the Actor to change the Logger logging level (e.g. `logging.getLogger().setLevel(logging.WARNING)`) so that those messages are dropped by the Logger and not forwarded to the Logging Actor. After Thespian 3.10.1, the minimum logging level in the logDefs supplied to the ActorSystem() initialization is applied to each Actor created and can be used to control the logging threshold even for Actors that don't dynamically change their level.

4.13.3 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.

THESPLOG_THRESHOLD specifies the minimum log level that will get written the **THESPLOG_FILE**. The default value is **WARNING** and the following log levels are recognized: **CRITICAL**, **ERROR**, **WARNING**, **INFO**, and **DEBUG**.

4.14 Actor Code Distribution

The Thespian ActorSystem provides a 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.

The Thespian Director document describes the Director utility and how it can help to use loadable Actor sources in a safe and practical manner.

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.

It is important to note that the Actor is not fully initialized until the `__init__` function completes, so no actor-level operations (e.g. `self.send()`, `self.createActor()`) should be performed in the class's `__init__` function. Actor initialization can be handled in the `receiveMessage` in a number of ways, including:

- detecting None values of members and replacing them with the results of initialization at that time
- Handling a specific initialization message sent by some other entity.
- A combination of the above, using the `initializing_messages` decorator provided by the `thespian/initmsgs.py` helper.

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,
                             sourceHash=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 `actorSystem.CapabilityCheck` 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 `actorSystem.CapabilityCheck()` 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 a system-wide singleton and to be uniquely identified and referenced in a manner additional to the ActorAddress of the actor.

The `sourceHash` argument, if specified, indicates a loaded source in which the `actorClass` should be found when attempting to load the `actorClass` source and start the Actor. See `ActorSys.createActor()` for more details.

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

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.

This is also especially surprising when modifying the implementation of the Actor and retrying; the new code will not seem to be running, and indeed it is not because the previous version of the code is still existing in the running Admin. The Admin must be stopped and restarted as part of the new code implementation to have that new implementation available to it.

3. Creating an actor inside the main `.py` file run from the command line and specifying the class object does not work because the module to which the class is assigned is `"__main__"`, which cannot be resolved by the Admin. There are two solutions:
 - (a) Place the Actor in a different file and import it explicitly from that file (which therefore correctly identifies that file as the module context for the Actor).
 - (b) Create a loadable module instead and reference the actor by a name/import-path string.

5.4 send

```
self.send(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(timePeriod, payload=None)
```

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.

The `payload` argument can be used to specify a value that is held by Thespian and returned in the `WakeupMessage` when the elapsed time has expired. The `payload` can be used by the Actor to provide context for the wakeup operation. The `payload` value is arbitrary, but it is accrued against the actor's memory until it is delivered; hence, it is recommended to keep the `payload` reasonably small.

5.6 handleDeadLetters

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

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

5.7 notifyOnSystemRegistrationChanges

```
self.notifyOnSystemRegistrationChanges(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()
```

This method registers the current Actor as the Source Authority handler for the current ActorSystem as described in the Security Considerations section of the loadActorSource ActorSystem 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 PEP302¹ 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 notifyOnSourceAvailability

```
self.notifyOnSourceAvailability(enable=True)
```

This method can be called to register or de-register (based on the enable argument) this Actor for being informed of loaded or unloaded source loads. Load notifications are delivered via the LoadedSource message and source unloads generate UnloadedSource messages to the notification registrant.

¹The 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.

Registration is with the local actor system only, and notifications are only for loads and unloads of available sources in the local system; remote registration and corresponding notifications are available, but are not triggered by local load or unload events.

5.12 actorSystemCapabilityCheck

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

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.

5.12.1 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
```

5.13 updateCapability

The `updateCapability()` method is used to 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(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.

5.14 preRegisterRemoteSystem

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

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

Normally ActorSystems 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 ActorSystems. This method will only work for ActorSystem bases that support Conventions (as describe in the Other Actor Systems section).

Because the remote System and the local 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(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 ActorSystem. If the specified string is not recognizable by the local ActorSystem, 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.

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

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

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

The `remoteSystemAddress` parameter may be specified in the same manner as for the `preRegisterRemoteSystem()` and is usually the same value that was originally passed to the latter method. The `remoteSystemAddress` parameter may also be an actual ActorAddress (e.g. the same address that would be provided in the ActorSystemConventionUpdate messages).

5.16 actorSystemShutdown

The `actorSystemShutdown()` method can be called by an actor to shutdown the **entire** local ActorSystem, including all Actors currently running under that system. This method should not normally be needed and is intended only for situations where the local running system is being deactivated.

The shutdown operation will be initiated immediately: ActorExitRequests will be sent to all locally running Actors.

```
self.actorSystemShutdown()
```

Use this method with caution.

5.17 ActorTypeDispatcher

An alternative base class for creating Actors is the `ActorTypeDispatcher` which extends the `Actor` base class. The `ActorTypeDispatcher` defines a `receiveMessage` method that 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
>>>

```

The `receiveMessage` method is defined by `ActorTypeDispatcher` so the actor subclassing it should not define that method; if the `receiveMessage` is defined in the subclass then it will override the `ActorTypeDispatcher`'s implementation and all message handling will revert to the subclass's `receiveMessage` method.

5.17.1 Derived Classes

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
>>>

```

The matching does not rely on import path specifications. In the following example, the creation of `Message2` requires import qualification, but the `ActorTypeDispatcher`-supported `receiveMsg_Message1` will match `Message1` without the import namespace prefix:

```

1 class Message1: ...
2 class Message2: ...

```

```

1 import messagedefs
2
3 class SendActor(ActorTypeDispatcher):
4     def receiveMsg_Message1(self, msg, sender):
5         self.send(sender, messagedefs.Message2())
6
7 class RcvActor(ActorTypeDispatcher):
8     def receiveMsg_Message2(self, msg, sender):
9         ...

```

5.17.2 Unrecognized Messages

Normally the ActorTypeDispatcher will quietly discard messages that do not match any of the type-related receive methods. 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'>
>>>

```

It is important to note that an Actor based on the ActorTypeDispatcher that is also using the 5.2.1 functionality should implement the receiveUnrecognizedMessage entrypoint to ensure that a proper ThespianWatch message is returned when an unrecognized message is received.

5.17.3 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 explicit `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. This leads to the following behavior:

ActorSystem(...) return an object which references an ActorSystem with the configuration specified by the arguments, creating a new ActorSystem if necessary. Subsequent calls with the same arguments will get an instance referencing that same ActorSystem.

ActorSystem() return an object which references any previous ActorSystem created by this process. If there is no ActorSystem, it will create one with the default parameters (currently defaulting to a "simpleSystem-Base" instance). This is a convenience mechanism for accessing an ActorSystem that may have been created elsewhere in the application where more specific knowledge regarding the creation parameters was available.

```
def start_system():
    cfg = read_config_file()
    ActorSystem(systemBase=cfg.system_base,
                capabilities = { 'foo'=cfg.foo_capability, ...},
                ...)

def do_something():
    mine = ActorSystem().createActor(MyActor)
    r = ActorSystem().ask(mine, 'ready?', timedelta(seconds=3))
    ...

if __name__ == "__main__":
    start_system()
    do_something()
```

The following is equivalent to the above, although it requires extra code to pass the actor system to the various components needing it:

```
def start_system():
    cfg = read_config_file()
    asys = ActorSystem(systemBase=cfg.system_base,
                      capabilities = { 'foo'=cfg.foo_capability, ...},
                      ...)

    return asys

def do_something(asys):
```

```

mine = asys.createActor(MyActor)
r = asys.ask(mine, 'ready?', timedelta(seconds=3))
...

if __name__ == "__main__":
    asys = start_system()
    do_something(asys)

```

ActorSystem(..., transientUnique=True) ensures that a new ActorSystem is created instead of retrieving a previously-created ActorSystem. Note that the other arguments should specify the configuration of the new ActorSystem, and global resource collisions (e.g. port names) will prevent the new ActorSystem from being created.

6.3 ActorSystem.shutdown

```
actorSys.shutdown()
```

The `shutdown()` ActorSystem method is used to terminate an ActorSystem 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 a system-wide singleton and 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 ActorSystem, or previously have been obtained from a remote ActorSystem; 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.
- If using the `simpleSystemBase` (currently the default if no base is specified on the initial `ActorSystem()` call) then timeouts are unlikely to work as expected. For example, an actor call that sleeps for 5 seconds and then sends a response will block all processing and the response will be delivered, even if the `ask()` specified a timeout shorter than the 5 seconds. Furthermore, if there are no actor messages to be propagated and handled, the `simpleSystemBase` call to `ask()` will return immediately and without waiting for any requested 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.

Just as with the `ask()` timeout, the `listen` timeout is not generally useful when using a `simpleSystemBase` actor base. The timeout will typically either be ignored while there is active work to be done, or the call will return immediately if the actor system is quiescent with no messages to be delivered.

6.8 private

The `tell()`, `ask()`, and `listen()` operations are used by external applications to communicate with Actors, but they only provide a single "address" for the external application. If the external application is multi-threaded, and different threads wish to communicate with actors, some mechanism to route responses to the proper thread is needed.

To accomplish this, the `ActorSystem.private()` method can be used to obtain a "private" context for a particular thread. While it exists, this context creates a unique endpoint for the external application's threads and ensures that response messages sent by actors are sent to the proper initiating thread.

The `private()` context is easy to use along with the `with` statement:

```
...
asys = ActorSystem()
...
[thread1:]
with asys.private() as mysys:
    r = mysys.ask(addr, message, timeout)
    if r is not None:
        mysys.tell(addr2, 'completed')
...
[thread2:]
with asys.private() as sys2:
    resp = sys2.ask(addr5, msg, timeout)
    print(resp)
```

In the above example, the response message sent by the actor at `addr` will properly be directed to `thread1`, and the response message sent by the actor at `addr5` will only be sent to `thread2`.

6.9 updateCapability

The `updateCapability()` method is used to 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 is 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.

6.10 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 PEP302¹ 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` is not added to the list of available sources, but there is no other feedback (excepting perhaps the `/tmp/Thespian.log` logfile).

6.10.1 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 conjunction 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 preferable 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).

6.10.2 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 ActorSystem 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 ActorSystem 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 ActorSystem. Different ActorSystems 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, ActorSystems joined together in a Convention can exchange sources on demand to satisfy Actor creation requests. sources exchanged between ActorSystems 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 provided 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.

The Thespian Director document describes the Director utility and how it can help to use loadable Actor sources in a safe and practical manner.

6.11 **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 source².

This effect of this call on running Actors' ability to access the unloaded source via imports or subsequent 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`).

²Note 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.

7.1.1 Attributes

- `.poisonMessage` is the original message causing the target Actor failures.
- `.details` may provide additional details (as a string) regarding the failure that caused the poison message return (e.g. the exception stack trace).

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.
- `.payload` specifies the payload value (if any) that the Actor specified on the original `.wakeupAfter()` call.

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 available.

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 may either simply discard this message and take no further action, or it may send a `ValidatedSource` message specifying `None` as the validated source. The latter is recommended since it allows immediate response handling for pending actors for that source; otherwise a source load timeout must expire before rejecting actor create requests for the rejected source load attempt.

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

At the present time, only `.py` sources are utilized; any `.pyc` or `.pyo` sources are ignored if present in the zipfile.

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 source file tree of `.py` files 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 ActorSystems that are part of the Convention).



At this time, only `.py` files are used from the loaded source: any `.pyc` or `.pyo` files are ignored.

This message may also be sent by the Source Authority with `None` as the data to indicate that the associated Source Hash is invalid and is being actively rejected.

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, or `None` to reject the load attempt.

7.10 LoadedSource

The `LoadedSource` object is delivered to an Actor that has registered to be notified on changes in the loaded sources available in the local ActorSystem. This message is generated by the ActorSystem itself.

This message indicates that the associated source module has been loaded successfully and is now available for creating new actors. This message is delivered to each `notifyOnSourceAvailability` registered notification target on the local system when the source has been loaded on that system; remote loads will cause corresponding notifications to registrants on those systems at such time as the loaded source is provided to that remote system.

This message is also delivered for each loaded source that is present at the time of the registration (via the `notifyOnSourceAvailability` system call).

7.10.1 Attributes

- `.sourceHash` – The hash value of the source that has been loaded and successfully registered.
- `.sourceInfo` – The text information field associated with the loaded source. This should be treated as informational; there is no specific format or content dictated.

7.11 UnloadedSource

The `UnloadedSource` object is delivered to an Actor that has registered to be notified on changes in the loaded sources available in the local ActorSystem. This message is generated by the ActorSystem itself.

This message indicates that the associated source module has been unloaded and is therefore unavailable for creating new actors.

7.11.1 Attributes

- `.sourceHash` – The hash value of the source that has been unloaded and de-registered.
- `.sourceInfo` – The text information field associated with the unloaded source. This should be treated as informational; there is no specific format or content dictated.

7.12 *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.

7.12.1 Attributes

The *Thespian_StatusReq* object has no attributes.

7.13 *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.

7.14 *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 Patterns and Helpers

The elements described in this section is supplemental to the base Thespian functionality. It is entirely possible to use Thespian without using any of the elements here, but these elements represent common patterns or helpers that can be used when developing a Thespian actor-based application.

The helpers describe here are all implemented via the Thespian API and do not make use of the Thespian implementation internals. If the helpers here do not provide the specific functionality needed for a particular use case, please feel free to consider them as examples for creating your own helpers.

8.1 Actor Troupe Support

The use of Actor Troupes is supported by importing the `thespian.troupe` file and adding a `@troupe()` decorator to the Actor definition. This decorator turns a regular Actor into a dynamic Actor Troupe, where multiple Actors are spun up on-demand to handle messages.

This pattern is especially useful for situations where multiple requests are received and processing individual requests may take some time to perform.

```
from thespian.troupe import troupe
```

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

The optional arguments to the troupe decorator are:

- `max_count` is the maximum number of actors in the troupe (defaulting to 10).
- `idle_count` is the default number of actors in the troupe when idle. As work is received, the number of actors will grow up to the `max_count`, but when there is no more work, the number of actors will shrink back down to this number. Note that there may be fewer than this number of actors present: actors are only created if work is received and there are no idle actors to handle that work.

The decorator usage above works very well for a simple worker actor that can perform all of the necessary work utilizing only the message sent to it; the actor can be turned into a troupe member with no change other than adding the decorator.

The arguments to the troupe decorator are static and are applied at the time the Actor source is loaded. However, it is possible to update the `max_count` and `idle_count` for the troupe dynamically at any time using either text strings or the `UpdateTroupeSettings` object:

```
r = ActorSystem().ask(troupeActor, "troupe:set_max_count=9")
assert r == "Set troupe max_count to 9"

r = ActorSystem().ask(troupeActor, "troupe:set_idle_count=4")
assert r == "Set troupe idle_count to 4"

r = ActorSystem().ask(troupeActor, UpdateTroupeSettings(max_count=10, idle_count=4))
assert isinstance(r, UpdateTroupeSettings)
assert r.max_count == 10
assert r.idle_count == 4
```

Note that the adjustments of the troupe max and idle counts do not necessarily immediately reduce the number of running troupe workers if the counts are adjusted lower; troupe workers are reduced after the worker has successfully completed work. Increasing either of these counts should make more workers available immediately though.

An actor which must interact with other actors to process the work requires additional modifications to allow the troupe manager to know when the actor has finished performing the work. A troupe member that has not fully performed the work and is exchanging messages with other actors to complete the work (or awaiting WakeupMessages) must set the `troupe_work_in_progress` attribute on self to `True`. Once the work is completed by a subsequent message delivery, it should set this attribute to `False`, which will cause the troupe manager to be notified that the actor is ready for more work.

- Failure to set the `troupe_work_in_progress` attribute to `True` on a multi-step actor will result in either (a) the actor receiving more work before it has completed the previous work, or (b) the actor will be killed by the troupe manager before finishing the work because the manager believes the actor is finished.
- Failure to reset the `troupe_work_in_progress` attribute to `False` will cause the troupe manager to never send any more work requests to the troupe actor, even if the latter is idle. The troupe actor will also never be killed until the troupe manager itself is killed.

Manipulating the `troupe_work_in_progress` member variable for non-troupe actors has no effect on their behavior and is safe to do.

8.2 Transient Actors

Some actors should automatically die at some period after they are initially used, or after they are last used. These actors are referred to as "transient" in contrast to normal actors that will persist until explicitly shutdown (either by themselves or by another Actor).

Implementing transient actors is made easier by importing the `thespian.transient` file and adding a `@transient()` or `@transient_idle()` decorator to the Actor definition.

The `transient` decorator cause the actor to exit at some time period after it receives its first message.

The `transient_idle` decorator causes the actor to exit at some time period after it has received its last message.

Both decorators default to a period of 10 seconds, and both take an optional `exit_delay` argument value that specifies an alternate time period. The time period should be a `datetime.timedelta` object.

```
from thespian.transient import transient_idle

@transient_idle(timedelta(seconds=3, milliseconds=250))
class BoredActor(Actor):
    ...

@transient()
class TempActor(Actor):
    ...
```

Note that a transient actor which is created but which never receives any messages does not exit; the timer for transient exit is only started after receipt of the actor's first message.

8.3 Initialization Messages

It is common for an Actor to require one or more messages to "initialize" the Actor and prepare it for normal operations.

The `thespian.initmsgs` module provides an `initializing_messages` decorator that can assist with managing this initialization.

This pattern is especially useful for Actors which need to receive multiple different messages to initialize their state before normal processing begins. Each message is stored in a corresponding attribute on the Actor class, and (unless `init_passthru` is True) no messages are delivered to the `receiveMessages` entrypoint until all of the initialization messages have been received.

```
from thespian.initmsgs import initializing_messages
@initializing_messages(initset, initdone=None, init_passthru=False)
```

The required argument to the `@initializing_messages` decorator is a list of tuples, where the first tuple value is the name of an attribute to be set on this actor and the second tuple value is the type of the corresponding message. If the tuple has three entries and the third is True, then when the message type is matched, an attribute corresponding to the first element plus the suffix `"_sender"` is set to the sender of that message.

If multiple initialization messages of the same type are received, the corresponding attribute will be set to the last messages received.

The `initdone` argument, if set, specifies a method name (as a string) that should be called when all initialization message have been received.

The `init_passthru` can be set to True to pass **all** messages received during initialization to the normal Actor handling; the default is false and init messages are discarded and non-init messages are saved and delivered after initialization is completed. (All `ActorSystemMessage` messages are treated as if `init_passthru` was True).

Example:

```
@initializing_messages([('init_m1', Msg1, True),
                        ('init_tgt', ActorAddress),
                        ('frog', str)],
                        initdone='init_completed')
class FooActor(ActorTypeDispatcher):
    def init_completed(self):
        self.send(self.init_m1_sender, 'Running')
    def receiveMsg_Croak(self, croakmsg, sender):
        self.send(sender, self.frog)
        self.send(self.init_m1_sender, self.init_m1)
        self.send(self.init_tgt, croakmsg)
```

This actor will wait for three different initialization messages (`Msg1`, an `ActorAddress`, and a string) and store each as an attribute, as well as storing the sender address for the `Msg1` message. When all three have been received,

the `init_completed` method is called, and then all Croak messages cause three messages to be sent. Note that any Croak messages received before all three initialization messages will be stored and delivered after initialization is complete.

This decorator is incompatible with the `@troupe` decorator.

This decorator must appear before the `@transient` or `@transient_idle` decorator:

```
@initializing_messages([('init_m1', Msg1, True),
                        ('init_tgt', ActorAddress),
                        ('frog', str)],
                        initdone='init_completed')
@transient(timedelta(seconds=2, milliseconds=250))
class FooActor(ActorTypeDispatcher): ...
```

8.4 Thespian Director

The Thespian Director is a support utility that provides functionality that makes it easier to use the Loadable Sources functionality provided by Thespian. It is possible to use loadable sources without using the Director, but it's easier to use the Director to provide a base set of support functionality.

See the Thespian Director document for more information on the Director.

8.5 RunCommand support

The `thespian.runcommand` helper module can be used to execute commands on the local system and collect results. This effectively encapsulates the Python `subprocess.Popen` functionality into an Actor which isolates the Popen operation, using messages to request the execution of a command and retrieve the results of the command.

See the docstrings in the `thespian/runcommand.py` file for more details and the `test/test_runcommand.py` file for example usage.

9 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 ActorSystem provides the message delivery and underlying Actor support functionality.

- The implementation of the ActorSystem 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 ActorSystem must be initially created to provide an environment for all Actors that are subsequently run within that ActorSystem; this creation is the responsibility of code in this external environment. When external code calls the `ActorSystem()` constructor, an ActorSystem is started if one is not already running.

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

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

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

9.1 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 tuple

usage *read-only*

description 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 tuple

usage *read-only*

description 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 number

usage *read-only*

description 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 string

usage *read-only*

description 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 number

usage *read-only*

description 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 string

usage *optional settable*

values Yes, No, LeaderOnly

default Yes

description This capability specifies whether or not this ActorSystem will accept sources loaded via remote ActorSystems 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 ActorSystem. If this capability is not specified, the default is **Yes** which will accept sources loaded on any of the remote ActorSystems that are part of the Convention.

9.2 **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 `string`

usage *read-only*

value `simpleSystemBase`

9.3 **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 `ActorSystem` 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 ActorSystem is limited to the lifetime of the process that created it.

The multiprocQueueBase uses Python's multiprocessing 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 inefficient 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 string

usage *read-only*

value multiprocQueueBase

Admin Address string

usage *read-only*

value ThespianQ

description the address for the Admin queue. This is an arbitrary string value.

Process Startup Method string

usage *optional settable*

values fork or spawn

default fork (Unix), or spawn (Windows)

description 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.

9.3.1 Potential issues

- The multiprocessingQueueBase is not efficient for non-adjacent actor messaging
- There is an unexplained, core-level concern about dropped messages/deadlocks for the queue messaging in overload conditions.

9.4 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 ActorSystem 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 string

usage *read-only*

value multiprocTCPBase

Admin Port number

usage *optional settable*

default 1900

description 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.

Convention Address.IPv4 tuple or string or array of tuples/strings

usage *optional settable*

examples ('123.45.6.78', 1923), 123.45.6.78:1923, host-a:1923, or 123.45.6.78

description 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.

If not specified, then this ActorSystem operates in isolation and cannot interact with other Actor Systems.

BETA This can be specified as a list of convention leader addresses. In this mode, if a leader is shut-down, the remaining convention will shift to using one of the other leaders in the list (providing a measure of fault-tolerance/high-availability for the convention). This is currently BETA functionality and should not be used in production, as there are likely future code updates needed to handle any subtle issues that arise from this functionality.

Admin Routing boolean**usage** *optional settable***default** False

description if this capability is present and has a true value, this indicates that all Actors in remote ActorSystems must send all messages to local Actors through the Admin. This is commonly used where the ActorSystem 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 affect on the way in which the Actors themselves are implemented; it only changes the way that the ActorSystem routes messages.

Outbound Only boolean**usage** *optional settable***default** False

description if this capability is present and has a true value then it means that this ActorSystem (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 boolean**usage** *read-only*

description 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 string**usage** *optional***values** fork, spawn, or forkserver**default** fork (Unix), or spawn (Windows)

description 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.



At startup, the `multiprocTCPBase` will attempt to determine the local IP address to use for registering Actor Addresses:

- If a Convention Leader is specified, then it will be the address on which it can communicate with that Convention Leader.
- If no Convention Leader is specified, it attempts to identify a public address (i.e. one that can communicate with IP address 8.8.8.8).

In a situation where neither of the above is appropriate or yields a useable address, the `THESPIAN_BASE_IPADDR` environment variable can be set to the IP address to use before starting Thespian; setting this environment variable overrides any address probing above, and setting it to a network address that is not accessible from the local machine will result in the inability to run any Actors.

9.5 `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 ActorSystem 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 string

usage *read-only*

value `~multiprocUDPBase`

Admin Port number

usage *optional settable*

default 1029

description 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.

Convention Address.IPv4 tuple or string or list of tuples/strings

usage *optional settable*

description 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 string

usage *optional*

values fork, spawn, or forkserver

default fork (Unix), or spawn (Windows)

description 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.

The multiprocUDPBase system base selects a local IP address to use for Actor Addresses in the same manner as described for the multiprocTCPBase above.

10 Potential Concerns

- Dropped messages
- Message size limitations

11 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). The Thespian Director document describes the Director utility that can optionally be used to enhance and support this latter method.

11.1 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 desirable 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."

11.1.1 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.