# Asynchronous Method Dispatch (AMD) in C++

The number of simultaneous synchronous requests a server is capable of supporting is determined by the number of threads in the server's thread pool. If all of the threads are busy dispatching long-running operations, then no threads are available to process new requests and therefore clients may experience an unacceptable lack of responsiveness.

*Asynchronous Method Dispatch (AMD)*, the server-side equivalent of AMI, addresses this scalability issue. Using AMD, a server can receive a request but then suspend its processing in order to release the dispatch thread as soon as possible. When processing resumes and the results are available, the server sends a response explicitly using a callback object provided by the Ice run time.

AMD is transparent to the client, that is, there is no way for a client to distinguish a request that, in the server, is processed synchronously from a request that is processed asynchronously.

In practical terms, an AMD operation typically queues the request data (i.e., the callback object and operation arguments) for later processing by an application thread (or thread pool). In this way, the server minimizes the use of dispatch threads and becomes capable of efficiently supporting thousands of simultaneous clients.

An alternate use case for AMD is an operation that requires further processing after completing the client's request. In order to minimize the client's delay, the operation returns the results while still in the dispatch thread, and then continues using the dispatch thread for additional work.

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## Enabling AMD with Metadata in C++

To enable asynchronous dispatch, you must add an `["amd"]` metadata directive to your Slice definitions. The directive applies at the interface and the operation level. If you specify `["amd"]` at the interface level, all operations in that interface use asynchronous dispatch; if you specify `["amd"]` for an individual operation, only that operation uses asynchronous dispatch. In either case, the metadata directive *replaces* synchronous dispatch, that is, a particular operation implementation must use synchronous or asynchronous dispatch and cannot use both.

Consider the following Slice definitions:

**Slice**

```
["amd"] interface I {
    bool isValid();
    float computeRate();
};

interface J {
    ["amd"] void startProcess();
    int endProcess();
};
```

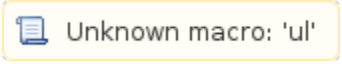
In this example, both operations of interface `I` use asynchronous dispatch, whereas, for interface `J`, `startProcess` uses asynchronous dispatch and `endProcess` uses synchronous dispatch.

Specifying metadata at the operation level (rather than at the interface or class level) minimizes the amount of generated code and, more importantly, minimizes complexity: although the asynchronous model is more flexible, it is also more complicated to use. It is therefore in your best interest to limit the use of the asynchronous model to those operations that need it, while using the simpler synchronous model for the rest.

## AMD Mapping in C++

The C++ mapping emits the following code for each AMD operation:

1. A callback class used by the implementation to notify the Ice run time about the completion of an operation. The name of this class is formed using the pattern `AMD_`*`class_op`*. For example, an operation named `foo` defined in interface `I` results in a class named `AMD_I_foo`. The class is generated in the same scope as the interface or class containing the operation. Several methods are provided:



Neither `ice_response` nor `ice_exception` throw any exceptions to the caller.

2. The dispatch method, whose name has the suffix `_async`. This method has a `void` return type. The first parameter is a smart pointer to an instance of the callback class described above. The remaining parameters comprise the in-parameters of the operation, in the order of declaration.

For example, suppose we have defined the following operation:

**Slice**

```
interface I {
    ["amd"] int foo(short s, out long l);
};
```

The callback class generated for operation `foo` is shown below:

**C++**

```
class AMD_I_foo : public ... {
public:
    void ice_response(Ice::Int, Ice::Long);
    void ice_exception(const std::exception&);
    void ice_exception();
};
```

The dispatch method for asynchronous invocation of operation `foo` is generated as follows:

**C++**

```
void foo_async(const AMD_I_fooPtr&, Ice::Short);
```

# AMD Exceptions in C++

There are two processing contexts in which the logical implementation of an AMD operation may need to report an exception: the dispatch thread (the thread that receives the invocation), and the response thread (the thread that sends the response).

These are not necessarily two different threads: it is legal to send the response from the dispatch thread.

Although we recommend that the callback object be used to report all exceptions to the client, it is legal for the implementation to raise an exception instead, but only from the dispatch thread.

As you would expect, an exception raised from a response thread cannot be caught by the Ice run time; the application's run-time environment determines how such an exception is handled. Therefore, a response thread must ensure that it traps all exceptions and sends the appropriate response using the callback object. Otherwise, if a response thread is terminated by an uncaught exception, the request may never be completed and the client might wait indefinitely for a response.

Whether raised in a dispatch thread or reported via the callback object, user exceptions are validated and local exceptions may undergo translation.

# AMD Example in C++

To demonstrate the use of AMD in Ice, let us define the Slice interface for a simple computational engine:

**Slice**

```
module Demo {
    sequence<float> Row;
    sequence<Row> Grid;

    exception RangeError {};

    interface Model {
        ["amd"] Grid interpolate(Grid data, float factor)
            throws RangeError;
    };
};
```

Given a two-dimensional grid of floating point values and a factor, the `interpolate` operation returns a new grid of the same size with the values interpolated in some interesting (but unspecified) way.

Our servant class derives from `Demo::Model` and supplies a definition for the `interpolate_async` method:

**C++**

```
class ModelI : virtual public Demo::Model, virtual public IceUtil::Mutex {
public:
    virtual void interpolate_async(
        const Demo::AMD_Model_interpolatePtr&,
        const Demo::Grid&,
        Ice::Float,
        const Ice::Current&);

private:
  std::list<JobPtr> _jobs;
};
```

The implementation of `interpolate_async` uses synchronization to safely record the callback object and arguments in a `Job` that is added to a queue:

**C++**

```
void ModelI::interpolate_async(
    const Demo::AMD_Model_interpolatePtr& cb,
    const Demo::Grid& data,
    Ice::Float factor,
    const Ice::Current& current)
{
    IceUtil::Mutex::Lock sync(*this);
    JobPtr job = new Job(cb, data, factor);
    _jobs.push_back(job);
}
```

After queuing the information, the operation returns control to the Ice run time, making the dispatch thread available to process another request. An application thread removes the next `Job` from the queue and invokes `execute` to perform the interpolation. `Job` is defined as follows:

**C++**

```
class Job : public IceUtil::Shared {
public:
    Job(const Demo::AMD_Model_interpolatePtr&, const Demo::Grid&, Ice::Float);
    void execute();

private:
    bool interpolateGrid();

    Demo::AMD_Model_interpolatePtr _cb;
    Demo::Grid _grid;
    Ice::Float _factor;
};
typedef IceUtil::Handle<Job> JobPtr;
```

The implementation of `execute` uses `interpolateGrid` (not shown) to perform the computational work:

**C++**

```
Job::Job(const Demo::AMD_Model_interpolatePtr& cb, const Demo::Grid& grid, Ice::Float factor) :
    _cb(cb), _grid(grid), _factor(factor)
{
}

void Job::execute()
{
    if (!interpolateGrid()) {
        _cb->ice_exception(Demo::RangeError());
        return;
    }
    _cb->ice_response(_grid);
}
```

If `interpolateGrid` returns `false`, then `ice_exception` is invoked to indicate that a range error has occurred. The `return` statement following the call to `ice_exception` is necessary because `ice_exception` does not throw an exception; it only marshals the exception argument and sends it to the client.

If interpolation was successful, `ice_response` is called to send the modified grid back to the client.

## See Also

- Asynchronous Method Invocation (AMI) in C++
- The Ice Threading Model
- User Exceptions
- Run-Time Exceptions