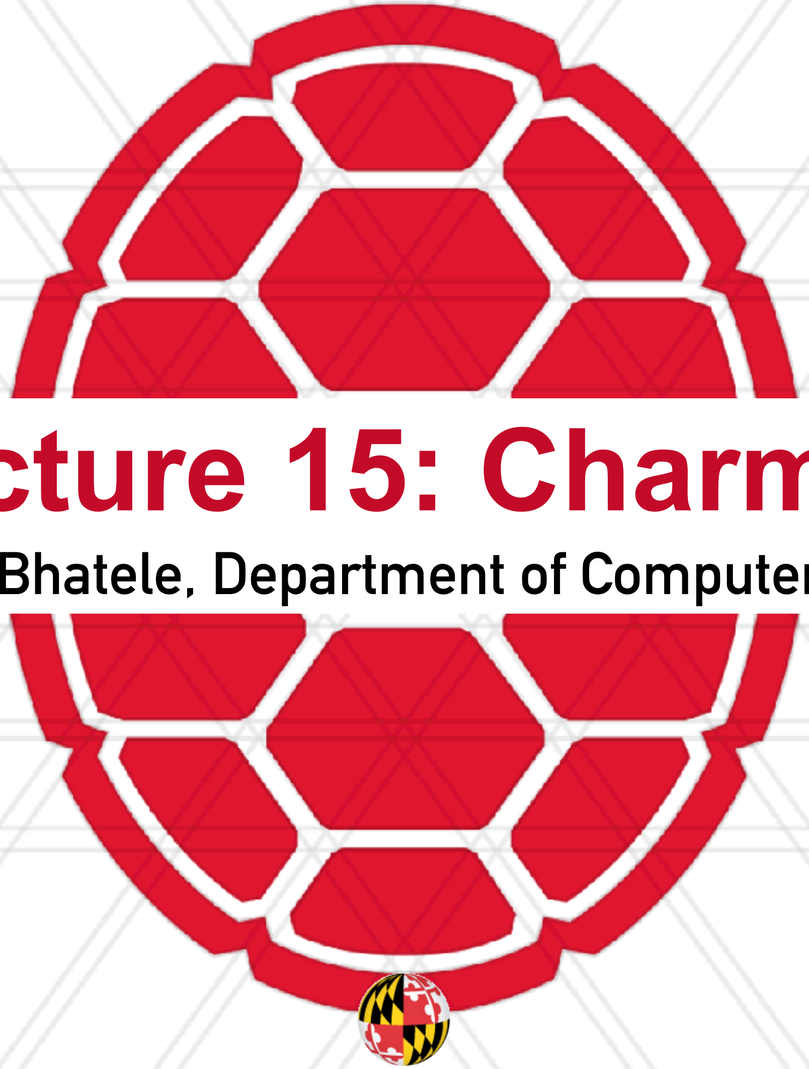
Introduction to Parallel Computing (CMSC498X / CMSC818X)



Lecture 15: Charm++

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Task-based programming models

- Describe program / computation in terms of tasks
- Tasks might be short-lived or persistent throughout program execution
- Notable examples: Charm++, StarPU, HPX, Legion
- Attempt at classification: https://link.springer.com/article/10.1007/s11227-018-2238-4

Charm++: Key principles

- Programmer decomposes data and work into objects (called *chares*)
  - Decoupled from number of processes or cores
- Runtime assigns objects to physical resources (cores and nodes)
- Each object can only access its own data
  - Request data from other objects via remote method invocation: foo.get_data()
- Asynchronous message-driven execution

Hello World in Charm++

```
mainmodule hello {

  array [1D] Hello {
    entry Hello();
    entry void sayHi();
  };

};
```

Charm++ Tutorial: http://charmplusplus.org/tutorial/ArrayHelloWorld.html

Hello World in Charm++

```
mainmodule hello {

  array [1D] Hello {
    entry Hello();
    entry void sayHi();
  };

};
```

```
void Hello ::sayHi() {
  CkPrintf("Hello from chare %d on processor %d.\n", thisIndex,
CkMyPe());
}
```

Charm++ Tutorial: http://charmplusplus.org/tutorial/ArrayHelloWorld.html

Hello World in Charm++

```
mainmodule hello {

  array [1D] Hello {
    entry Hello();
    entry void sayHi();
  };

};
```

```
Main::Main(CkArgMsg* msg) {
  numObjects = 5; // number of objects

  CProxy_Hello helloArray =
          CProxy_Hello::ckNew(numObjects);

  helloArray.sayHi();
}
```

```
void Hello ::sayHi() {
  CkPrintf("Hello from chare %d on processor %d.\n", thisIndex,
CkMyPe());
}
```

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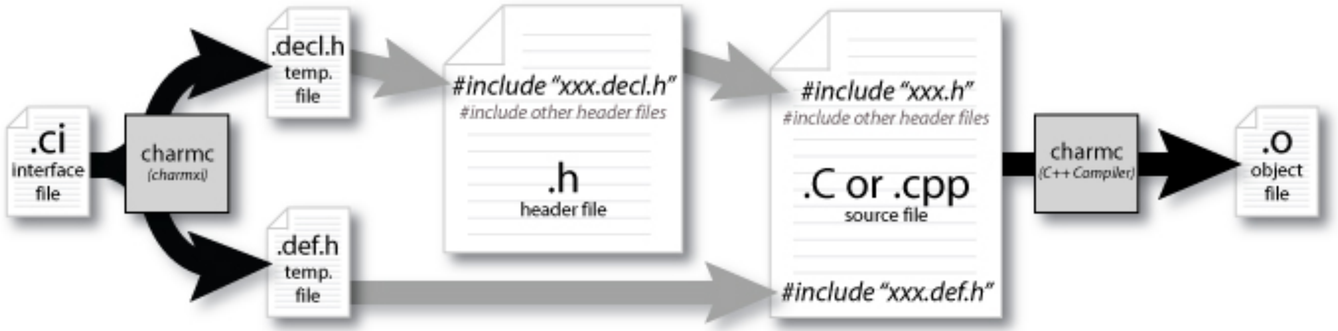
Compiling a charm program

- Charm translator for .ci file
  - Generates charm_hello.decl.h and charm_hello.def.h

```
charmc hello.ci
```

- C++ code:

```
charmc -c hello.C
charmc -o hello hello.o
```



Chare arrays

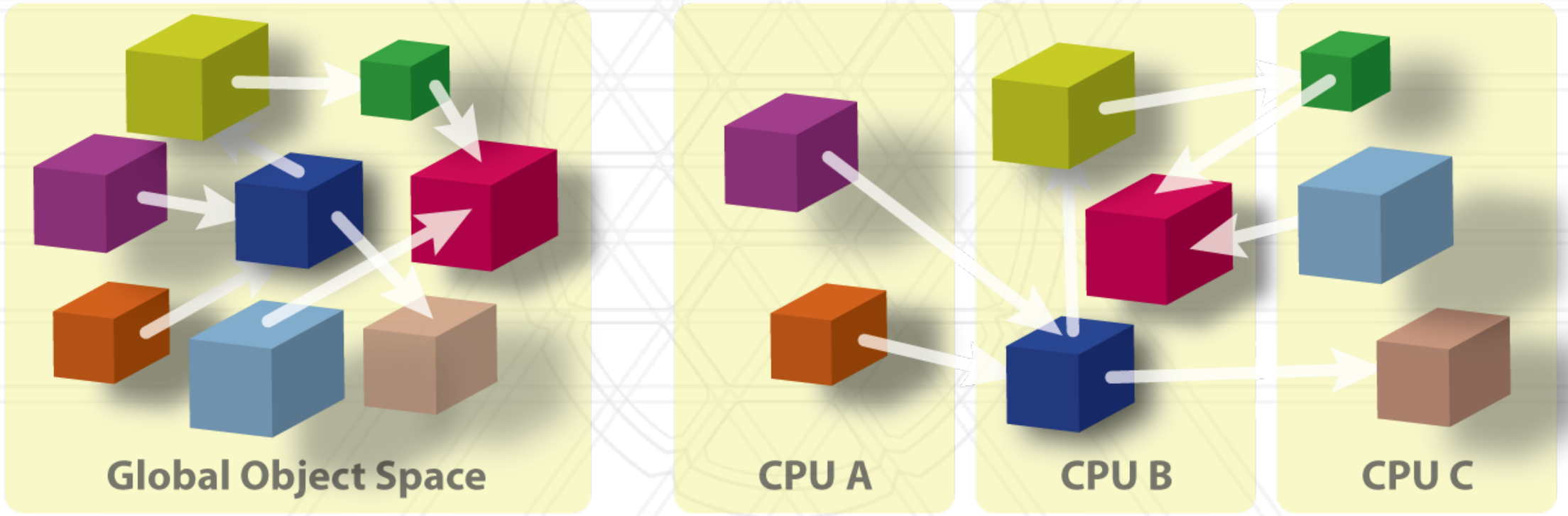
- User can create indexed collection of data-driven objects

```
CProxy_Hello helloArray = CProxy_Hello::ckNew(numElements);
```

- Different kinds: 1D, 2D, 3D, …
- Mapping of array elements (objects) to hardware resources handled by the runtime system (RTS)

Object-based virtualization

- User programs in terms of chares or objects



User View

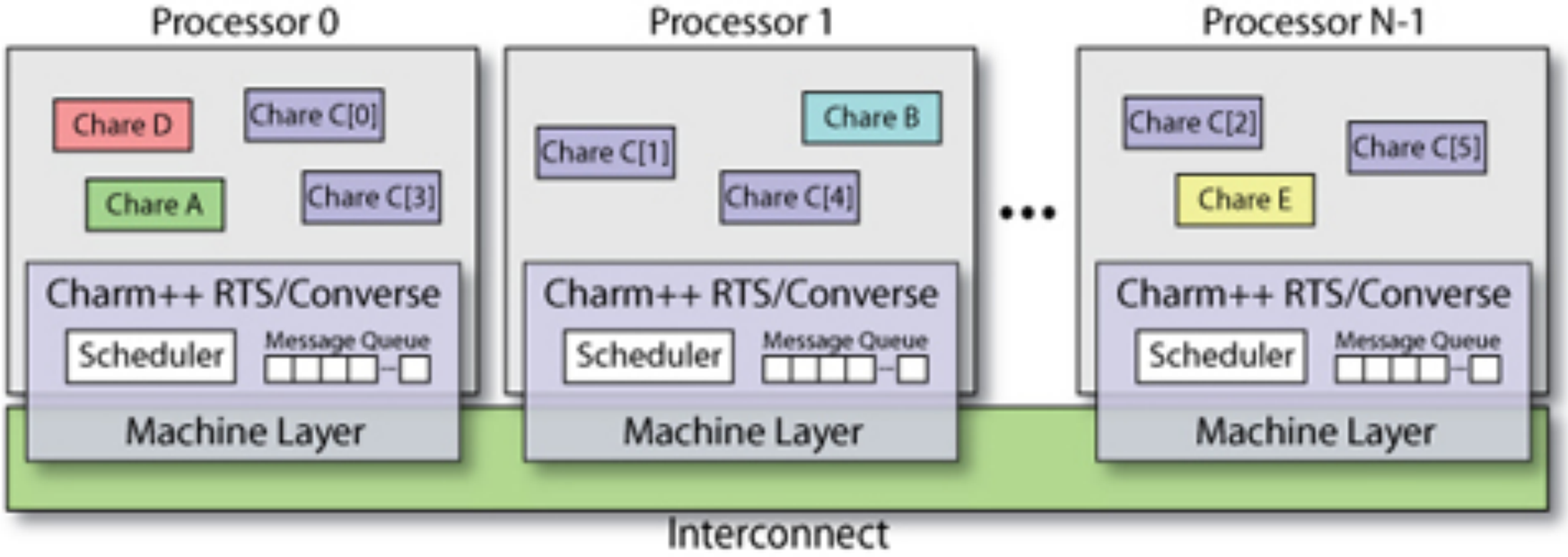
System View

Over-decomposition

- Create lots of "small" objects per physical core
  - Objects grouped into arrays: 1D, 2D, …
- System assigns objects to processors and can migrate objects between physical resources
- Facilitates automatic load balancing

Message-driven execution

- An object is scheduled by the runtime scheduler only when a message for it is received
- Facilitates adaptive overlap of computation and communication



Cost of creating more objects?

- Context switch overhead
- Cache performance
- Memory overhead
- Fine-grained messages

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