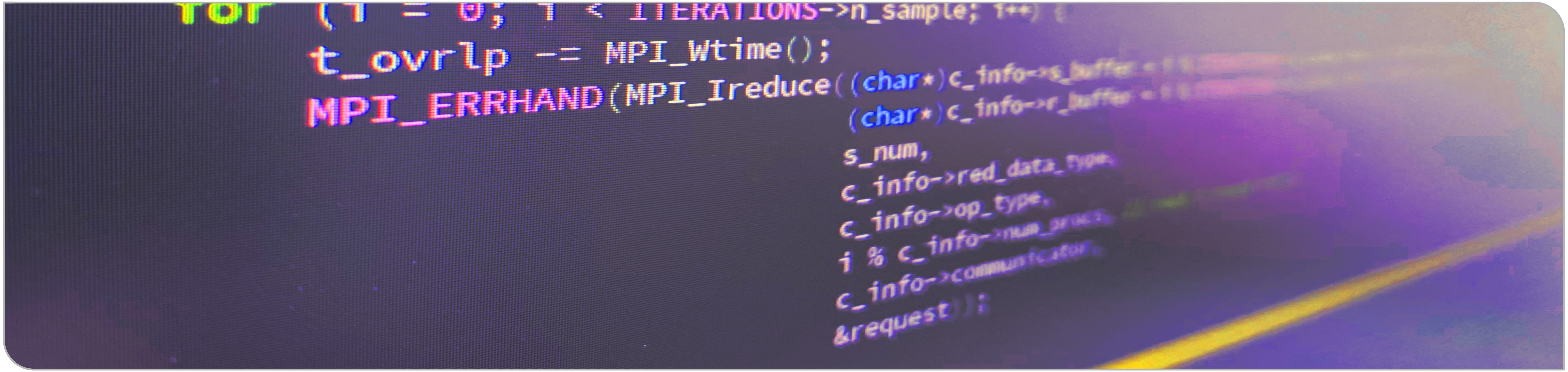
KIT
Karlsruhe Institute of Technology

(Near) Zero-Overhead C++ Bindings for MPI

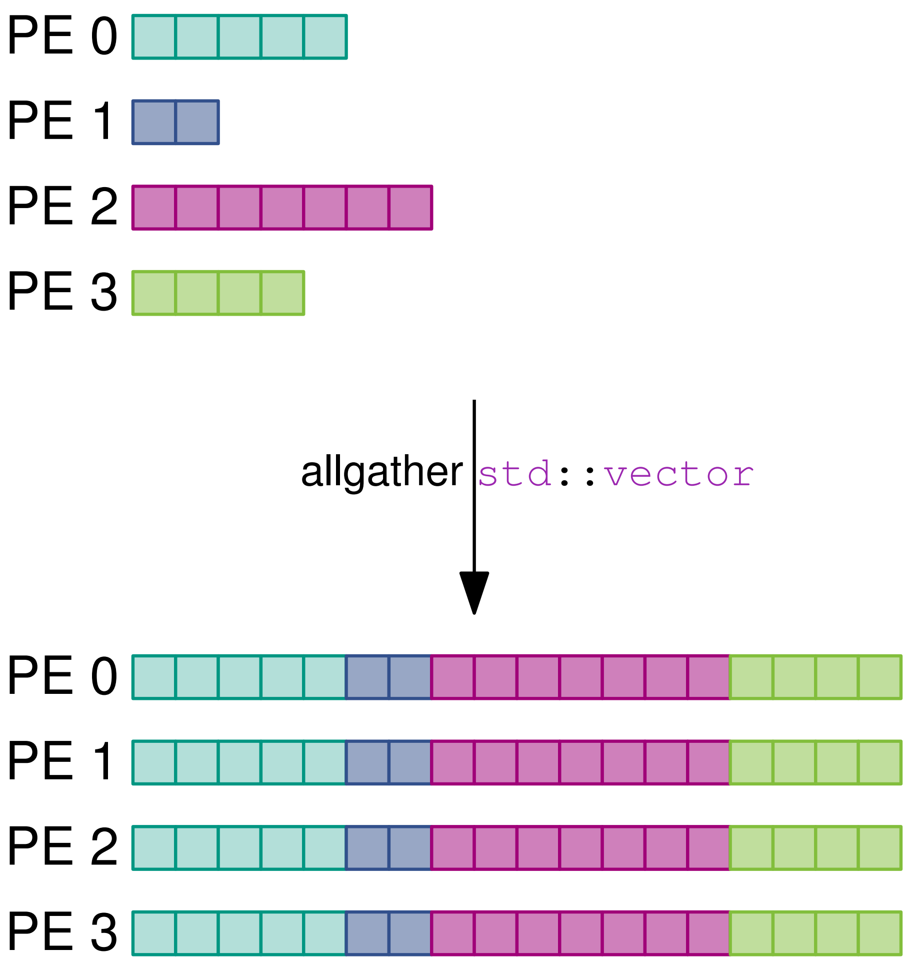
Brief Announcement @ SPAA'24 · June 19, 2024

Demian Hespe, Lukas Hübner, Florian Kurpicz, Peter Sanders,
Matthias Schimek, Daniel Seemaier, **Tim Niklas Uhl**

KaMPIng



Using MPI from C++



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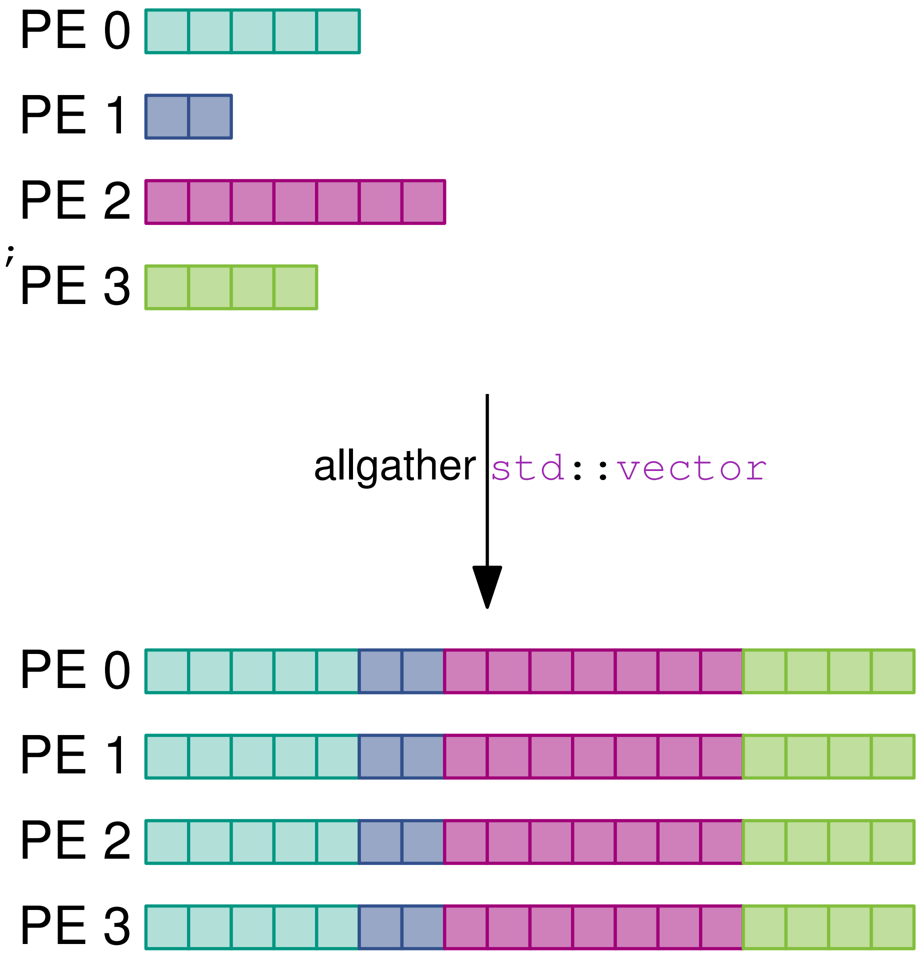

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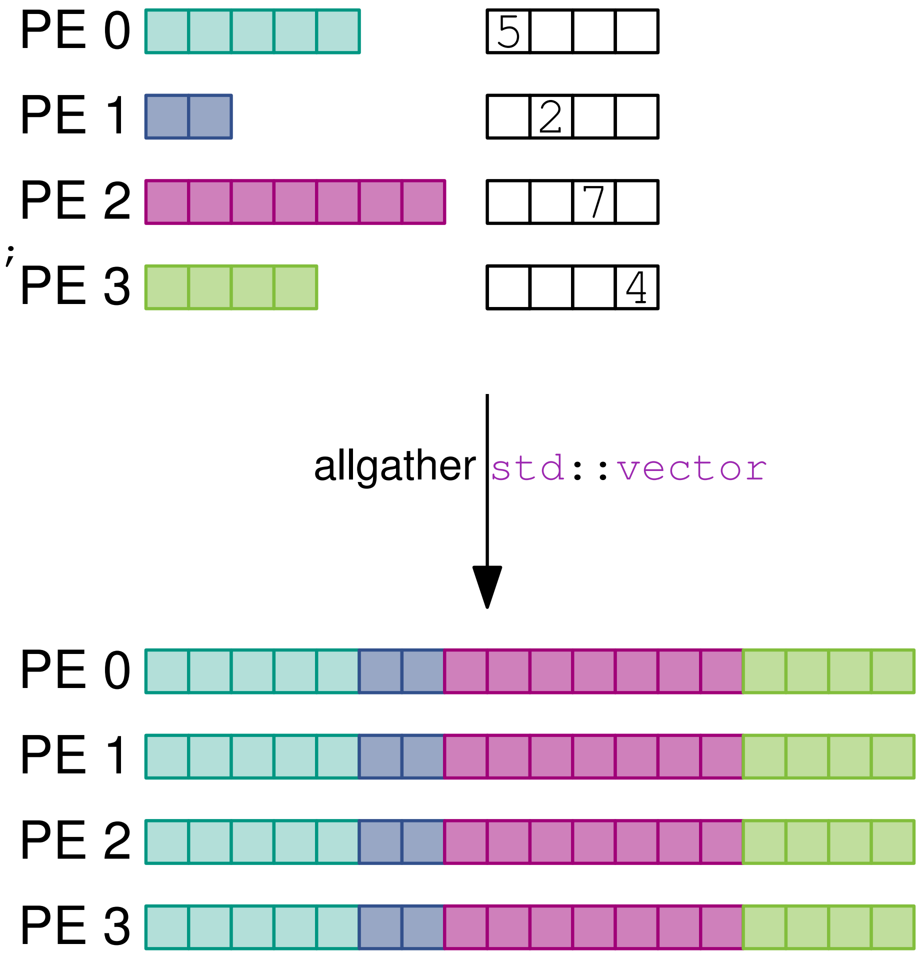

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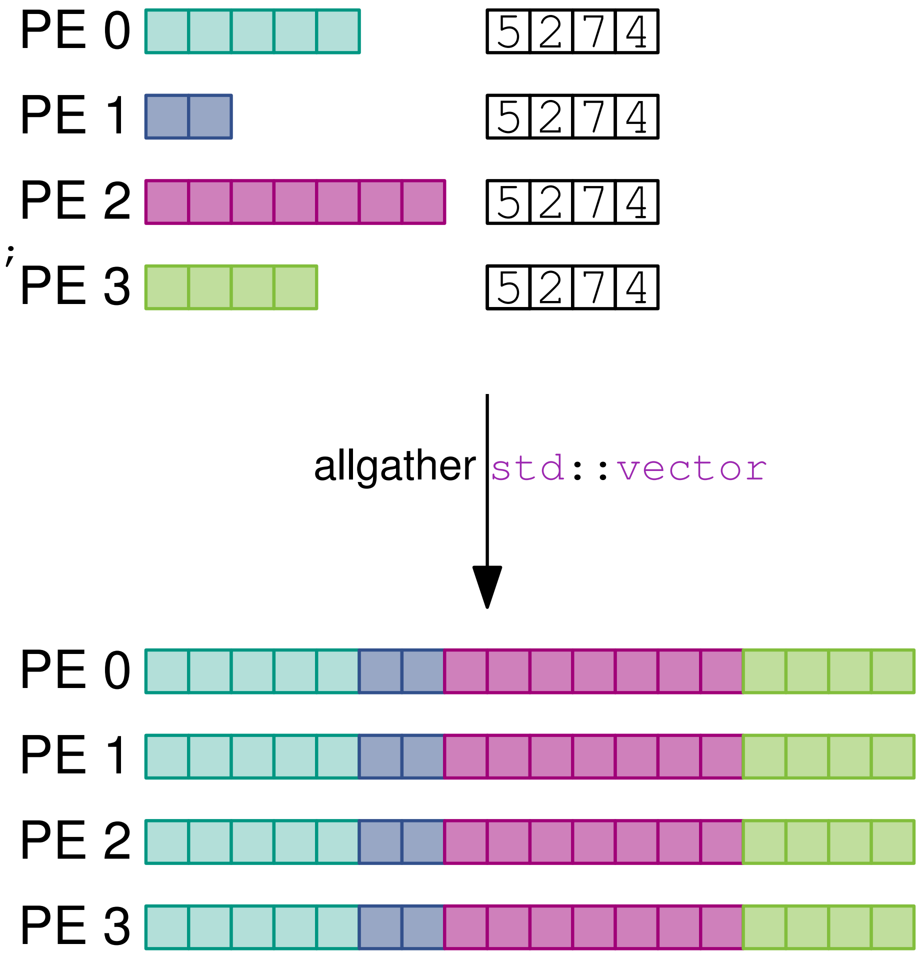

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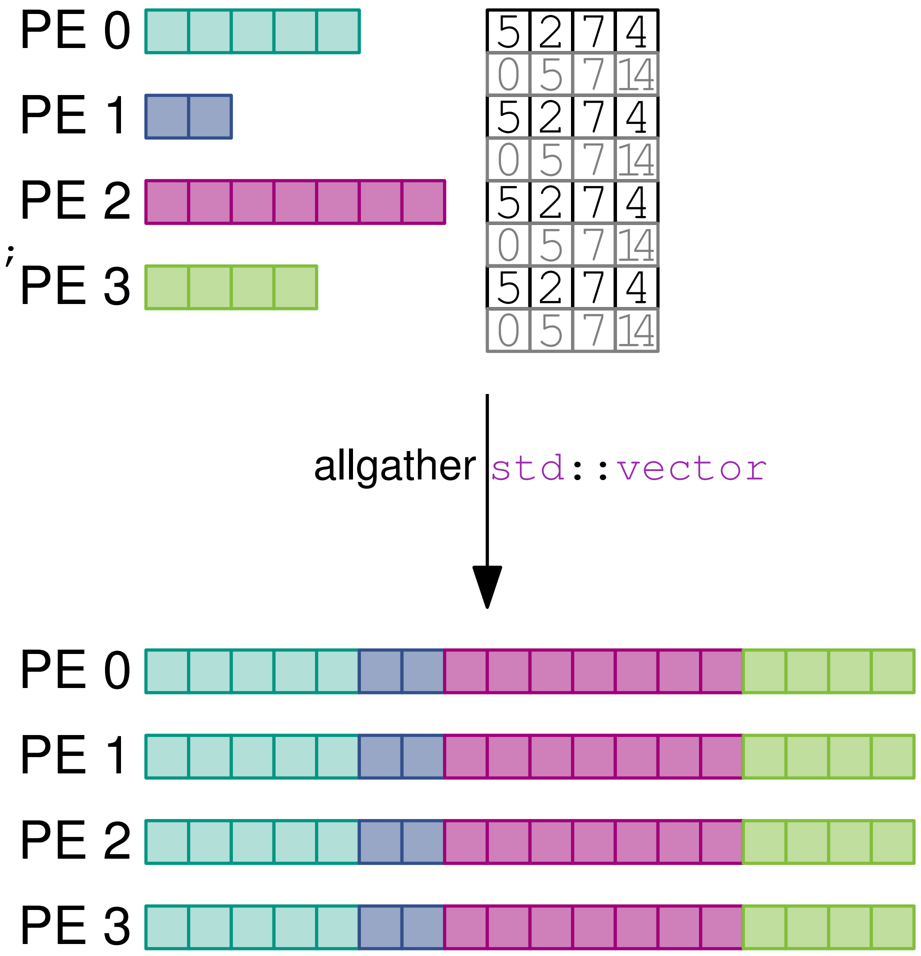

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Goals of KaMPIng:

Karlsruhe **MPI** **n**ext **g**eneration

- ☐ zero-overhead **abstraction** over MPI
- ☐ covering whole abstraction **range**: rapid prototyping ↔ highly engineered algorithms
- ☐ flexible **parameter handling**, sensible defaults
- ☐ configurable **memory management**
- ☐ compatible with **move semantics**

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C-ish API

all other parameters can be inferred

parameter order?

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arbitrary parameter order!

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return by reference

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or by value

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```
// avoid implicit allocation
comm.allgatherv(send_buf(v_local),
                recv_counts_out<no_resize>(some_buf));

// pass buffer ownership to calls
rc = comm.allgatherv(send_buf(v_local), recv_buf(v_global),
                     recv_counts_out<resize_to_fit>(std::move(rc)));

// retrieve auxiliary data
auto [recvbuf, counts] = comm.allgatherv(send_buf(v_local),
                                         recv_counts_out());
```

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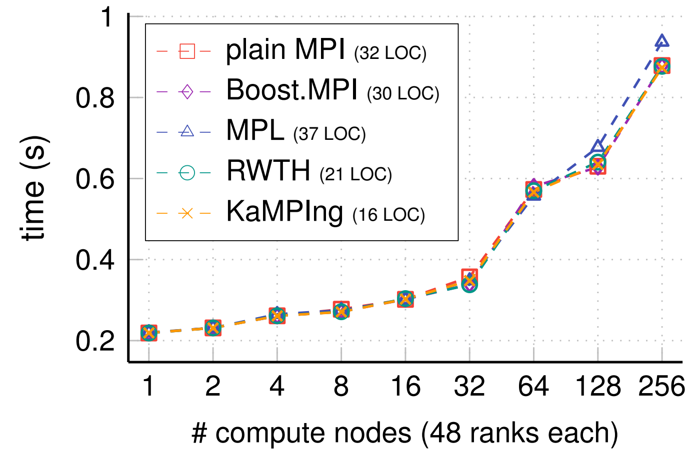
Conclusion

- **low-to-high-level** C++ bindings for MPI
- no runtime-overhead
- reduce boilerplate and error-proneness in MPI applications
  - default parameters
  - safety guarantess
  - fine-grained memory management
- base for a future **standard library** of distributed algorithms and data structures



application benchmarks:
- phylogenetic interference
- graph analysis/partitioning
- (string) sorting

github.com/kamping-site/kamping

This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No. 882500).

History of MPI and C++

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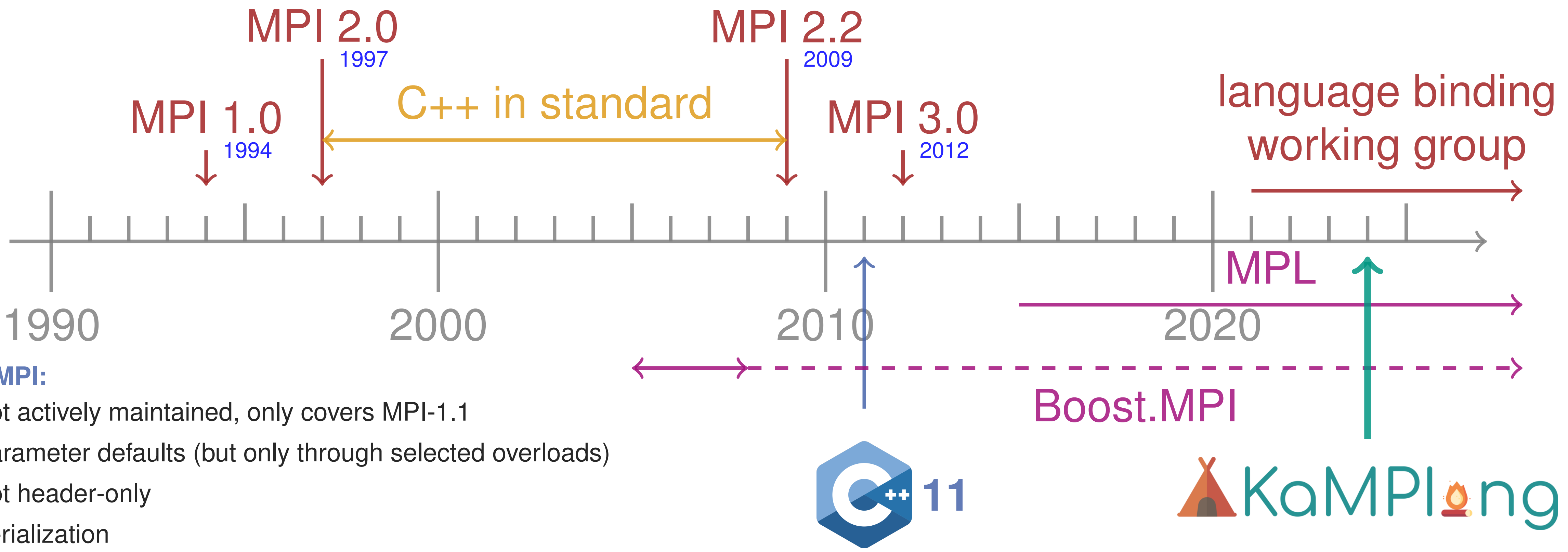

Boost.MPI:

– not actively maintained, only covers MPI-1.1
+ parameter defaults (but only through selected overloads)
– not header-only
+ serialization
– type system tightly coupled with serialization $\longrightarrow$ performance pitfalls

MPL:

+ powerful type system, suitable for scientific computing
– more complex irregular collectives via custom types $\longrightarrow$ less performant
– low abstraction level

More Features

Serialization

```
using dict = std::unordered_map<std::string, std::string>;
dict data = ...;
comm.send(send_buf( as_serialized(data)));

dict recv_dict = comm.recv(
  send_buf( as_deserializable<dict>())
);
```

Memory Safety for Nonblocking Operations

```
std::vector<int> v = ...;
auto r1 = comm.isend(
    send_buf_out(std::move(v)), destination(1)
);

v = r1.wait(); // v is moved back to caller after
               // request is complete

auto r2 = comm.irecv<int>(recv_count(42));
std::vector<int> data = r2.wait(); // data only returned
                                   // after request
                                   // is complete
```

Specialized Collectives