CORAL Server Project

Design and Development Proposal for Client, Server and Proxy

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CORAL Server Internal Review, 8th December 2008

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Proposed design guidelines

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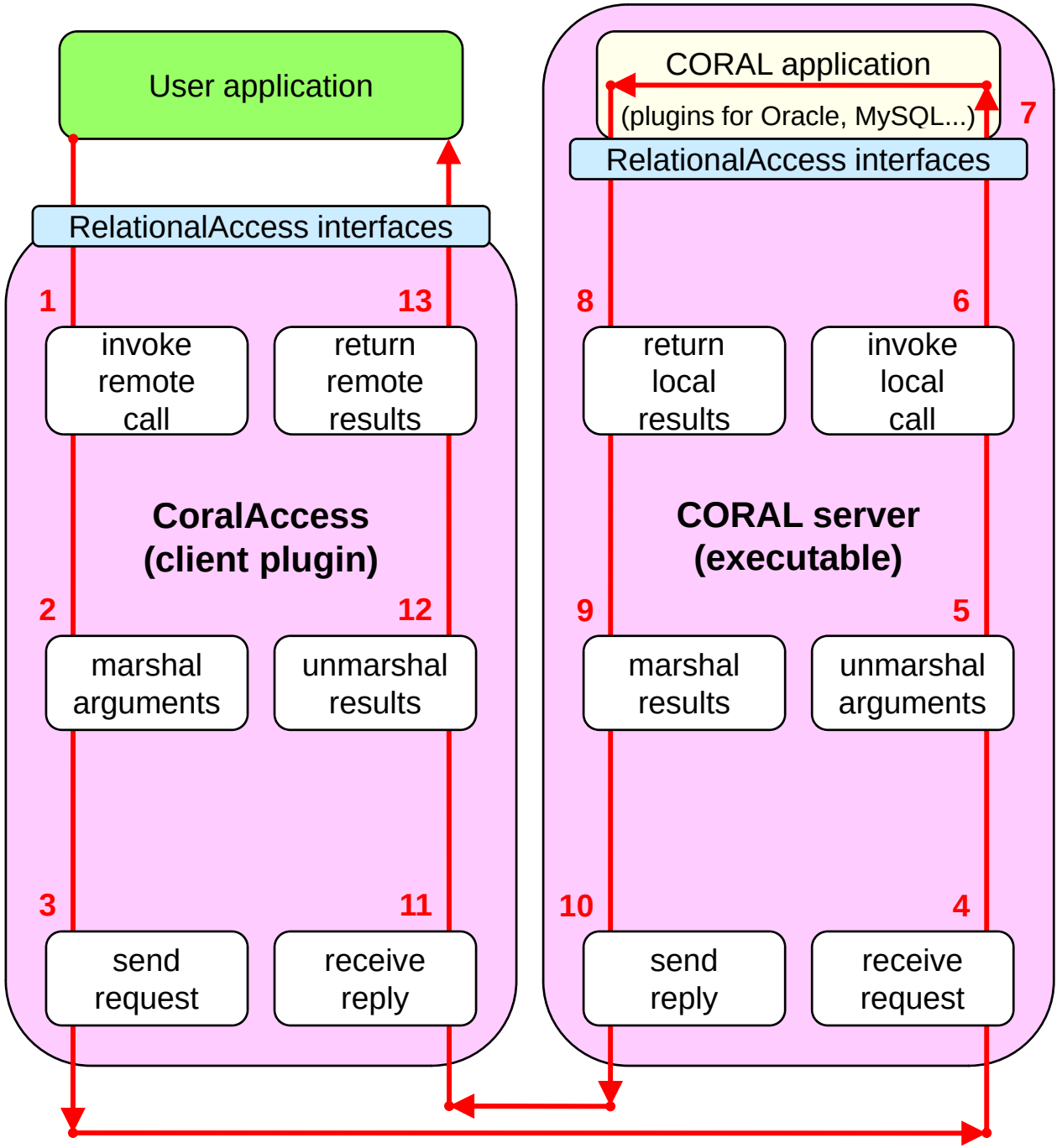
- **Joint design of server/client/proxy components**
  - Software collaboration vs. TCP packet contract
  - Development model: ‘horizontal’ vs. ‘vertical’
- **Allow several people to work independently**
  - Minimize software dependencies and couplings
- **Promote standalone tests of components**
  - Try to intercept bugs before they show up in system tests
- **Modular design favoring iterative development**
  - Allow upgrade of one component without touching the others
- ***Decouple components using abstract interfaces***
  - Minimize size of public headers: thin interfaces, simple constructors
  - Encapsulation: hide implementation details within each component


User application
RelationalAccess interfaces
1
invoke remote call
13
return remote results
CoralAccess (client plugin)
2
marshal arguments
12
unmarshal results
3
send request
11
receive reply
CORAL application
(plugins for Oracle, MySQL...)
7
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6
invoke local call
CORAL server (executable)
9
marshal results
5
unmarshal arguments
10
send reply
4
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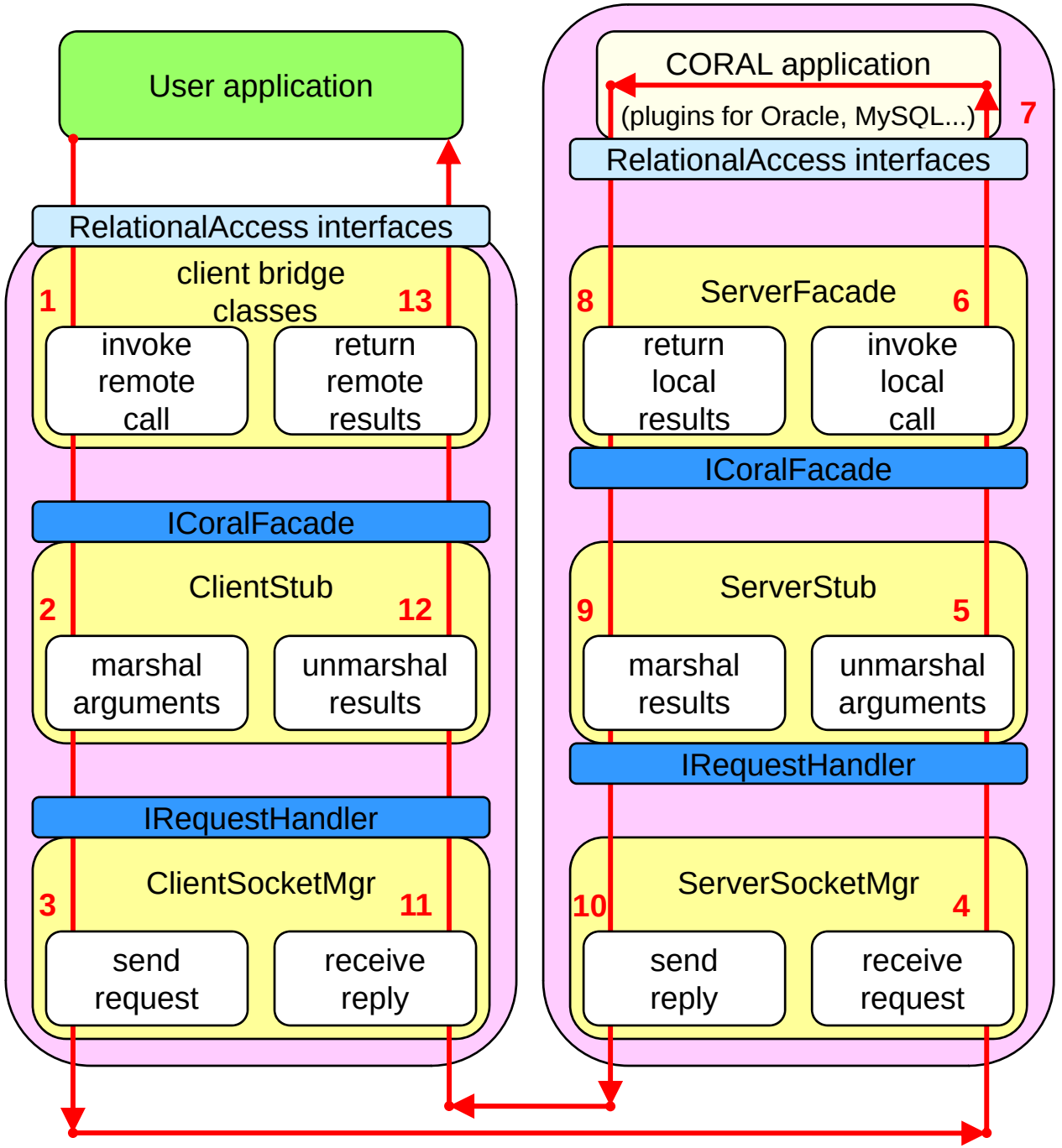
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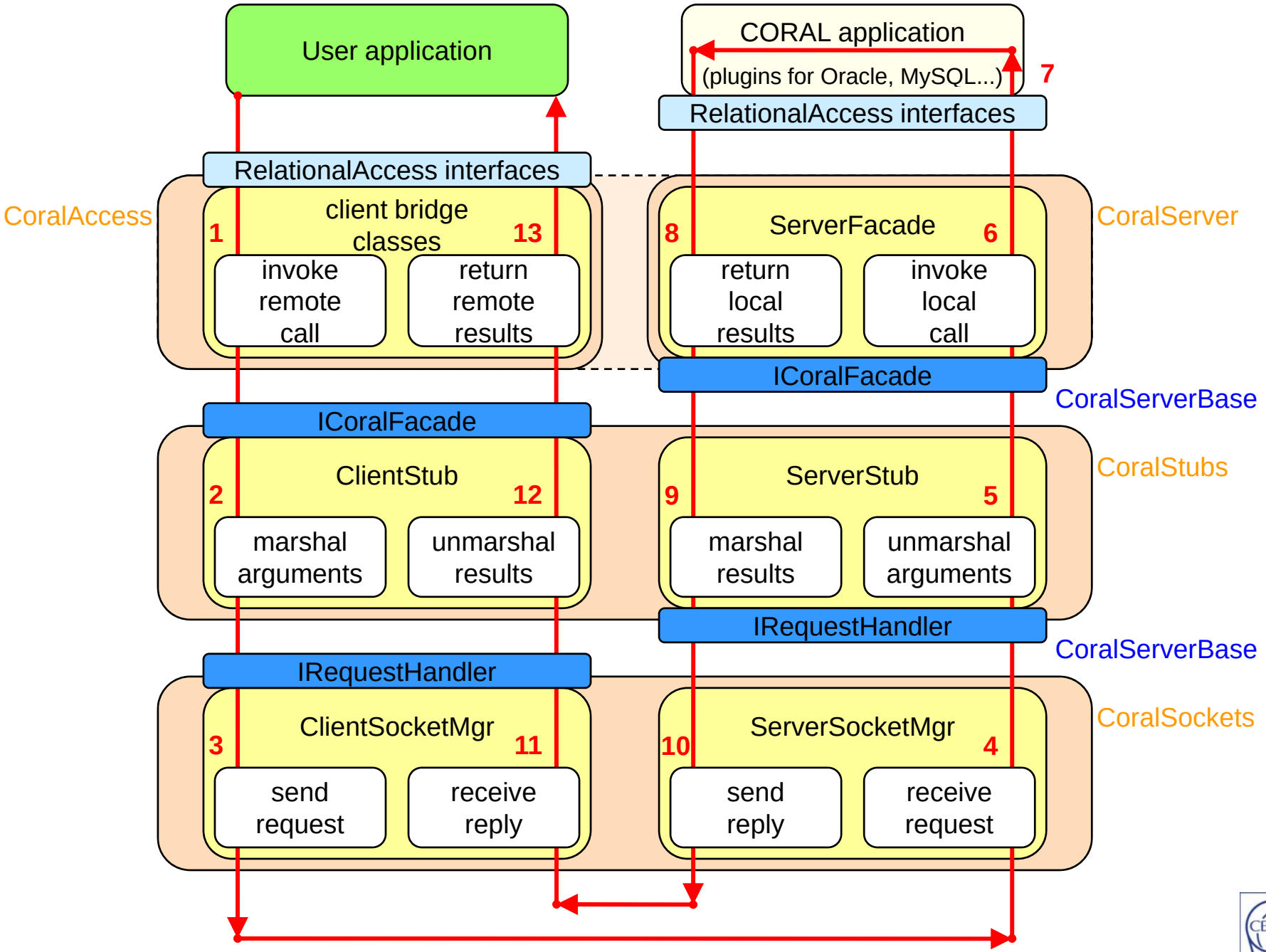
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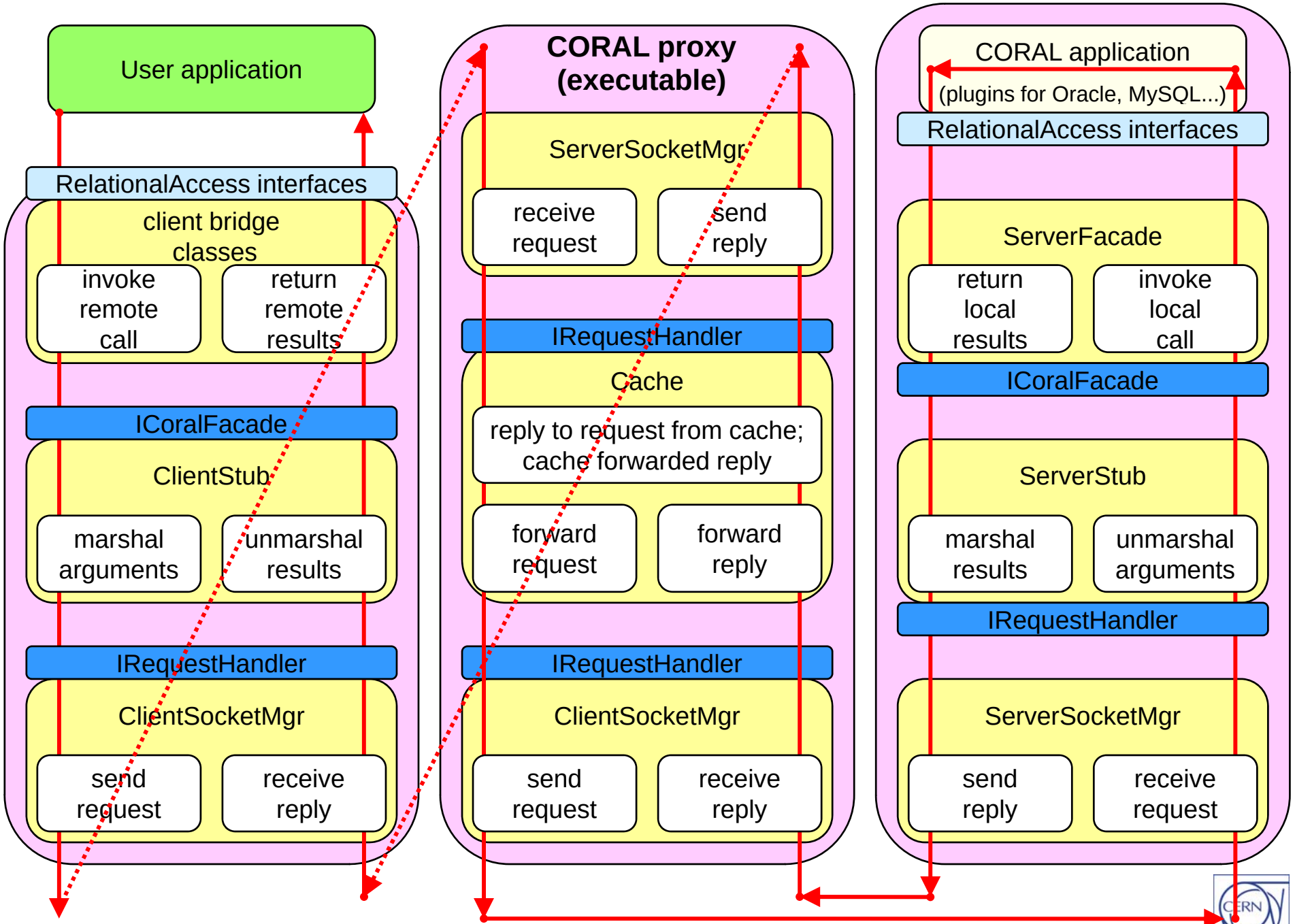
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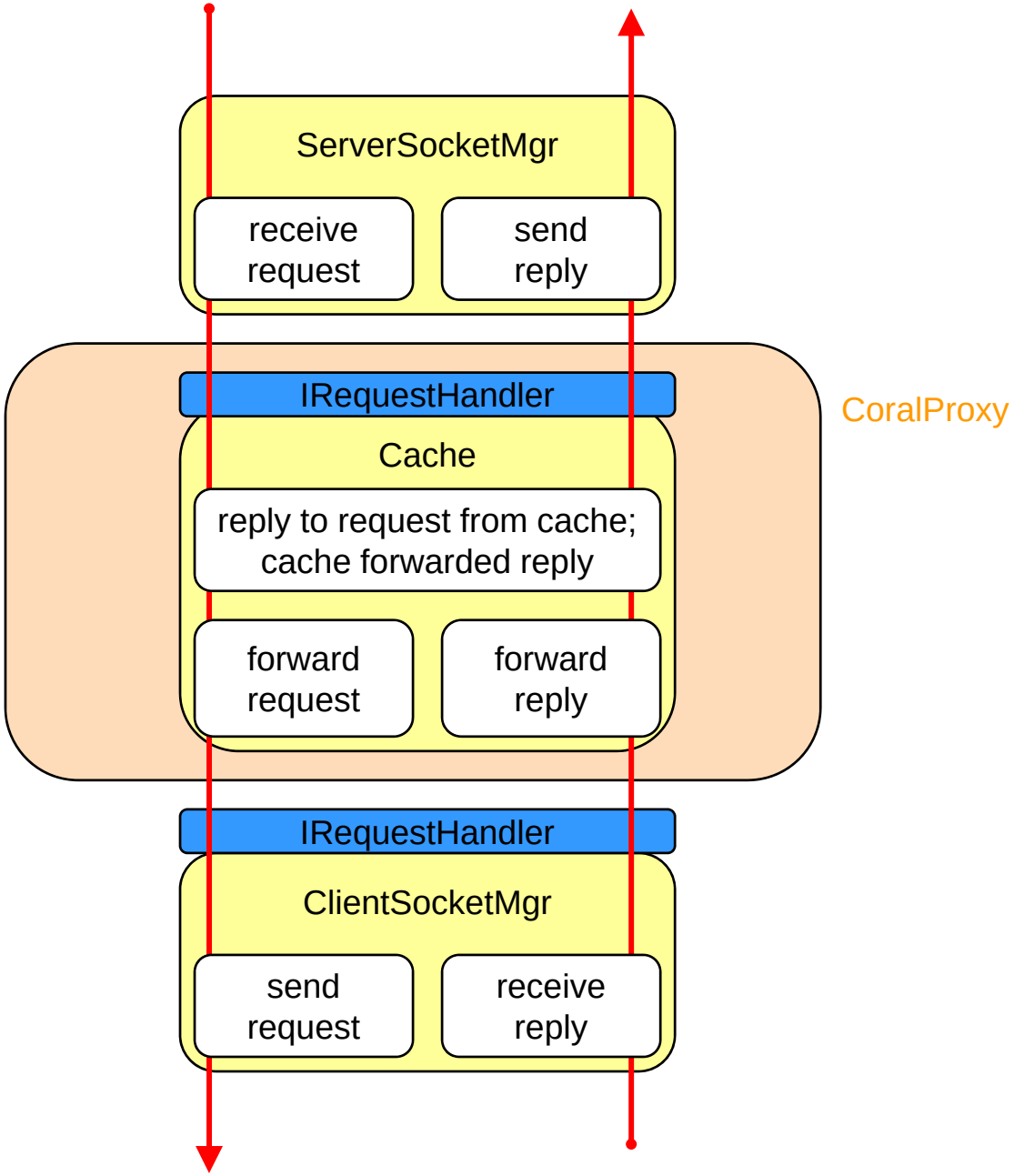
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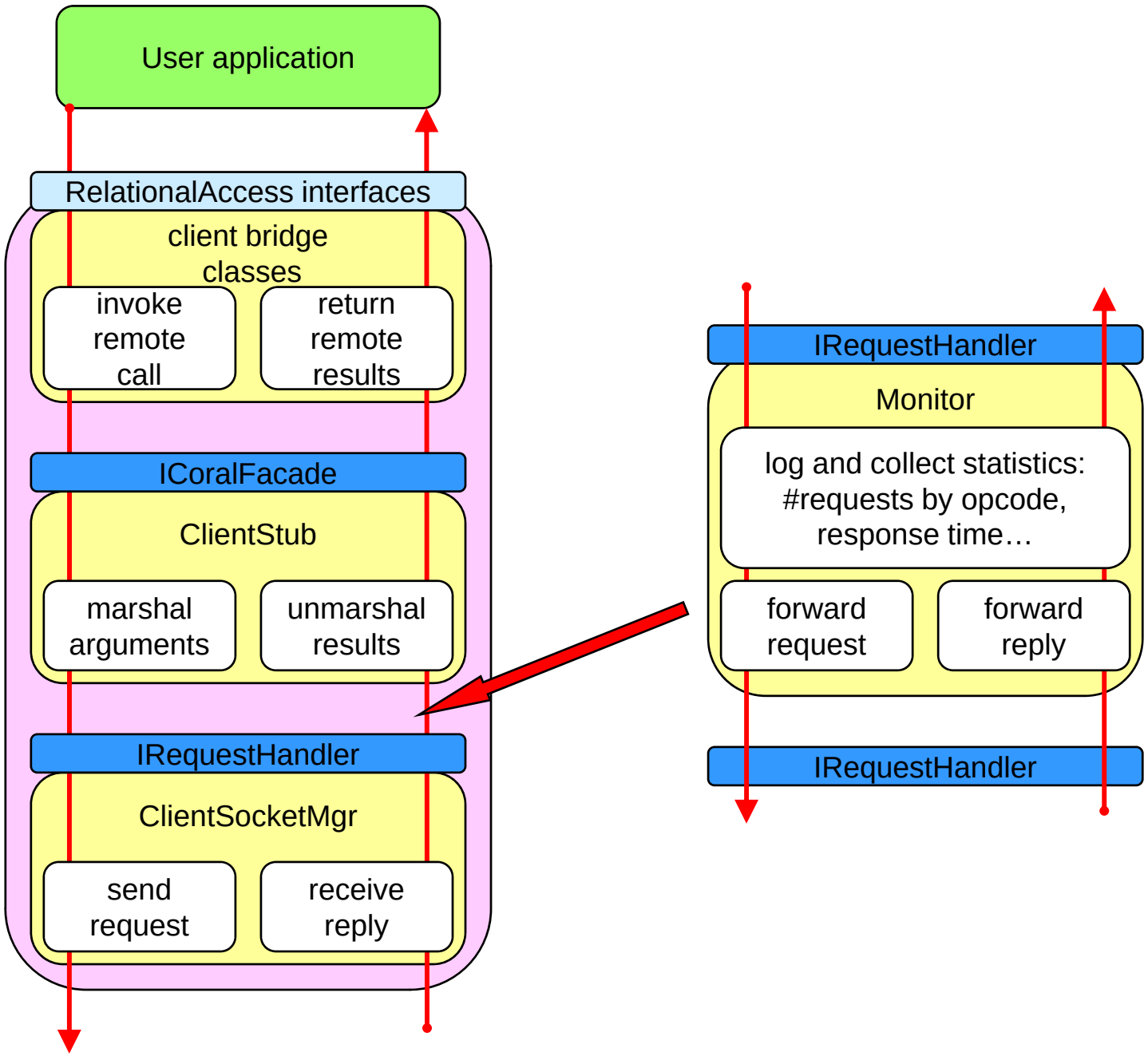
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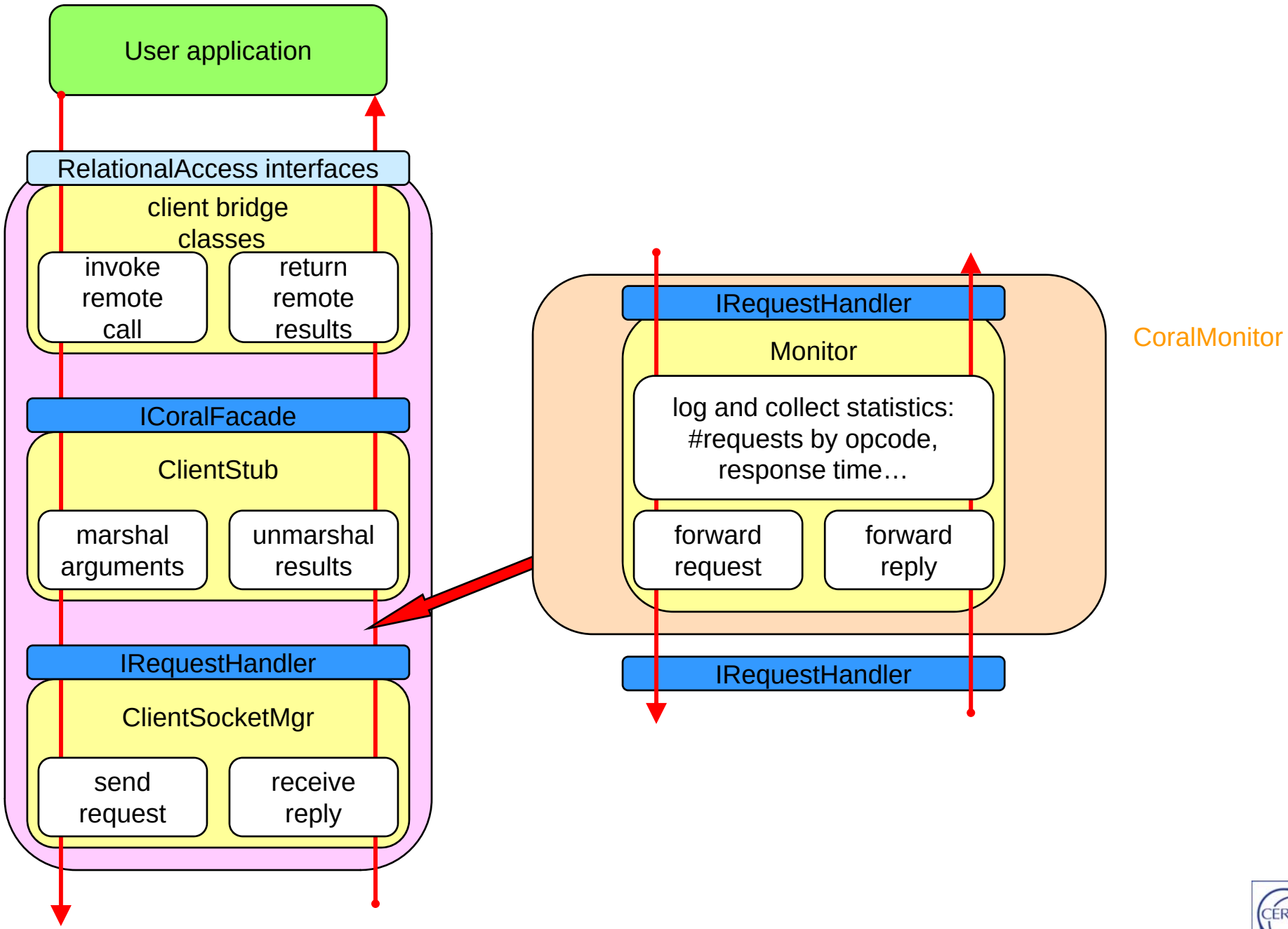
forward reply
IRequestHandler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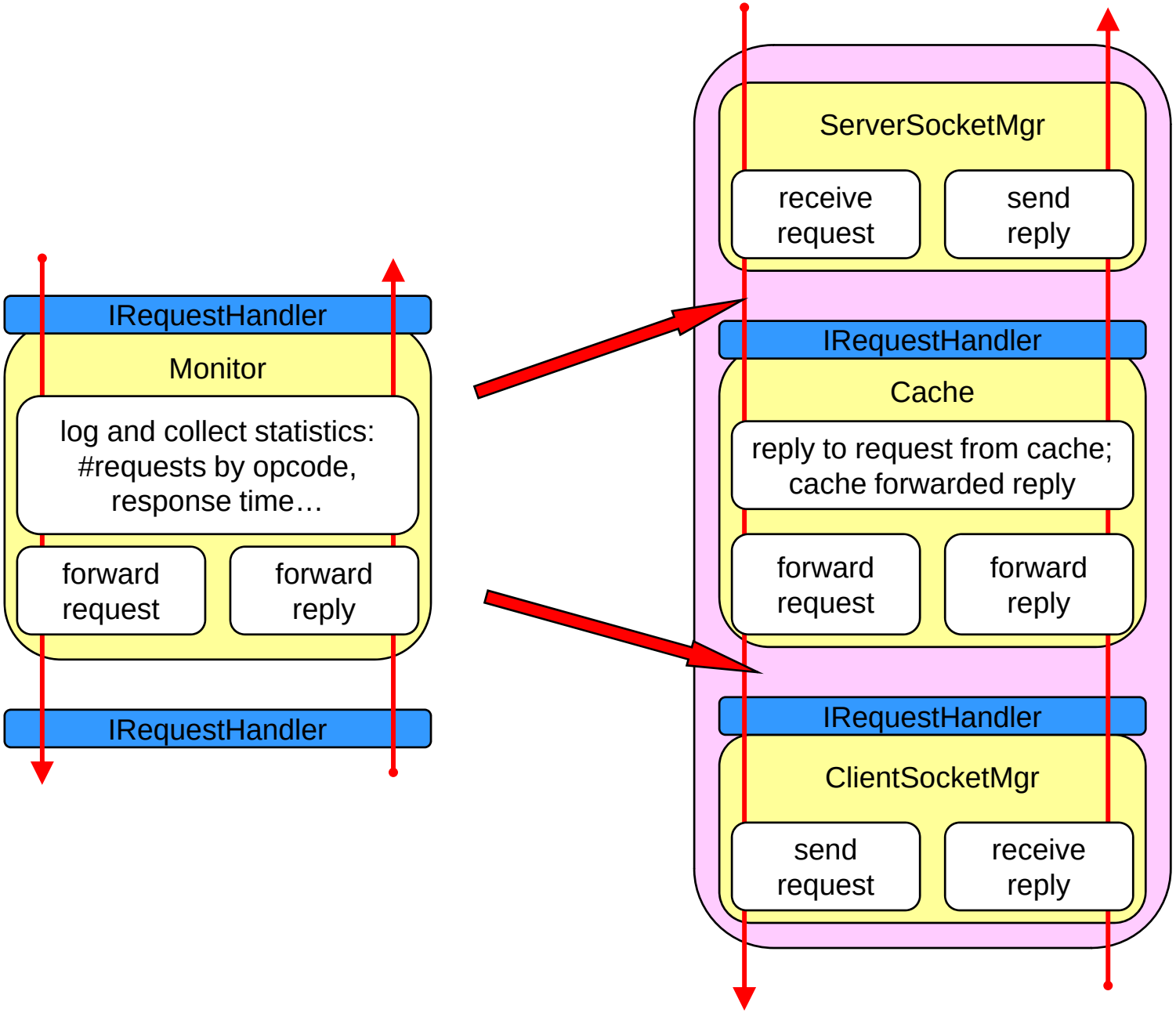
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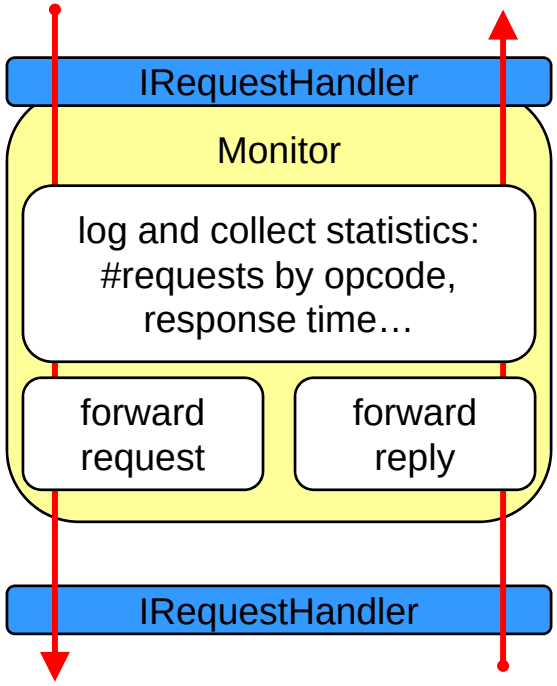
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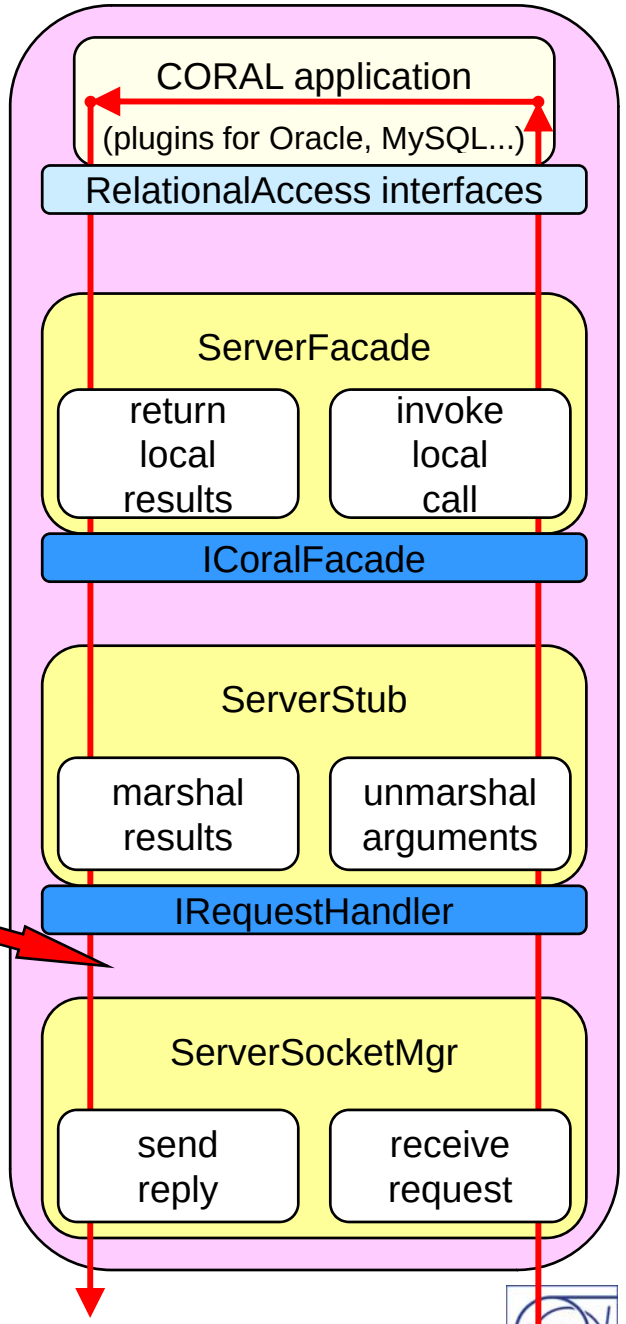
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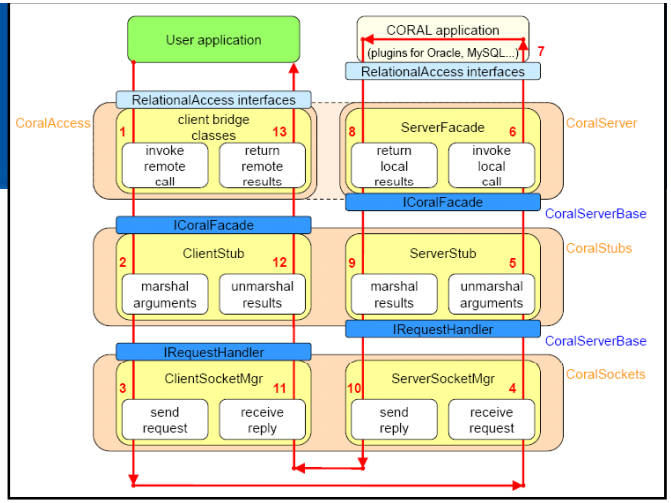
Package 1 – interfaces



- *In my diagram:* ***CoralServerBase***

- Two main sets of abstract interfaces
  - ICoralFacade (all relational operations that need network roundtrips)
    - Auxiliary interfaces: query definition, …
  - IRequestHandler (get string reply to a string request)
    - Auxiliary interfaces: handler factories, message (byte stream), …

- A few common classes may also be needed
  - Dummy request handler for tests
  - Adapter of a string request to extract relational header

Package 1 – interfaces

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- ICoralFacade
  - This defines what relational info needs to be shipped on the network (and how/when to do that)
    - Some CORAL API calls do not need network round trips
    - Example: split query definition (local) from query execution (remote)
    - Minimise network round trips by deferring and grouping them
  - Link request type to reply type
    - If you send a 'fetchRows' request message via sockets, the reply message must contain a list of rows (or an exception)

- IRequestHandler
  - Do not assume that exchanged messages will be relational
    - Reorder fields in agreed packet header: first those needed for low-level socket management (endian, size…); then the relational ones (opcode, cacheable...), treated as part of the request/reply string
  - Need optimization to avoid data copy overhead

Package 1 – interfaces

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```
class IRequestHandler
{
public:
  /// Destructor.
  virtual ~IRequestHandler(){}

  /// Handle a request message and return a reply message.
  /// The ownership of the reply message is delegated to the caller.
  virtual std::auto_ptr<const IMessage> replyToRequest( const IMessage& request ) = 0;
};
```

Or even better, replace
  const std::string&
by
  const coral::Blob*

```
class IMessage
{
public:
  /// Destructor.
  virtual ~IMessage(){}

  /// The message payload for this request/reply.
  virtual const std::string& payload() const = 0;
```

Package 1 – interfaces

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```
/// ObjectID type used for sessionID, cursorID, bulkOperationID (valid Token's are always > 0).
typedef int Token;

class ICoralFacade
{
public:
  /// Destructor.
  virtual ~ICoralFacade(){}
  [...]

  /// Create a new session and return its sessionID.
  virtual const Token connect( const std::string& dbUrl,
                               const coral::AccessMode mode = coral::Update ) const = 0;

  /// Release a session
  virtual void releaseSession( const Token sessionID ) const = 0;
  [...]

  /// Create a new cursor for the given query and return its cursor ID.
  virtual const Token executeQuery( const Token sessionID,
                                    const IPortableQueryDefinition& qd ) const = 0;

  /// Release a cursor
  virtual void releaseCursor( const Token cursorID ) const = 0;

  /// Fetch a new bulk of rows from the given cursor.
  virtual const std::vector<coral::AttributeList> fetchRows( const Token sessionID,
                                                             const Token cursorID,
                                                             const unsigned int maxSize ) const = 0;

  /// Fetch all rows from the cursor.
  virtual const std::vector<coral::AttributeList> fetchAllRows( const Token sessionID,
                                                                const IPortableQueryDefinition& qd ) const = 0;
  [...]
};
```

Package 1 – interfaces

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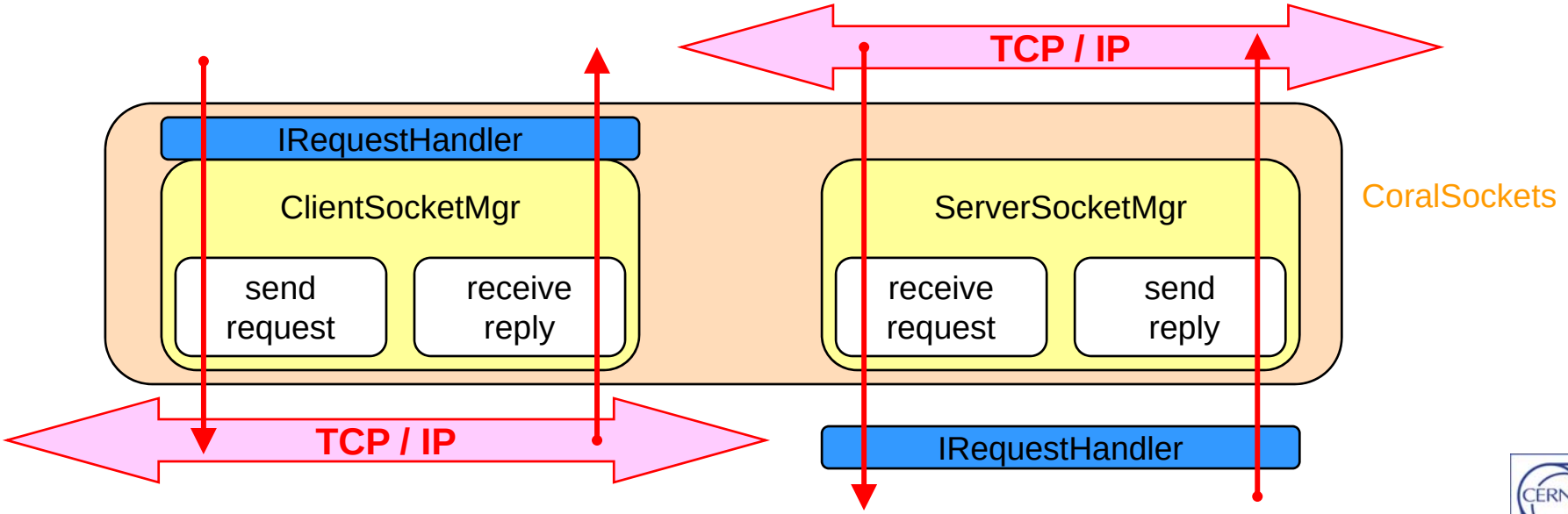
- Proposed team: ALL (need stable interfaces)
  - ICoralFacade: mainly Andrea, Alex
  - IRequestHandler: mainly Martin, Andy, Alex
- Standalone tests of the CoralServerBase package?
  - Very few tests needed (mainly an interface definition package)
- Possibilities for reuse of existing code
  - Interfaces from the old prototype following this design
  - Limited use of abstract interfaces in the present code

Package 2 – sockets (+threads)

- *In my diagram:* ***CoralSockets***

- Client-side: ClientSocketMgr
  - Implements IRequestHandler, sends requests over TCP/IP
- Server-side: ServerSocketMgr
  - Receives requests via TCP/IP, delegates to an IRequestHandler



Package 2 – sockets (+threads)

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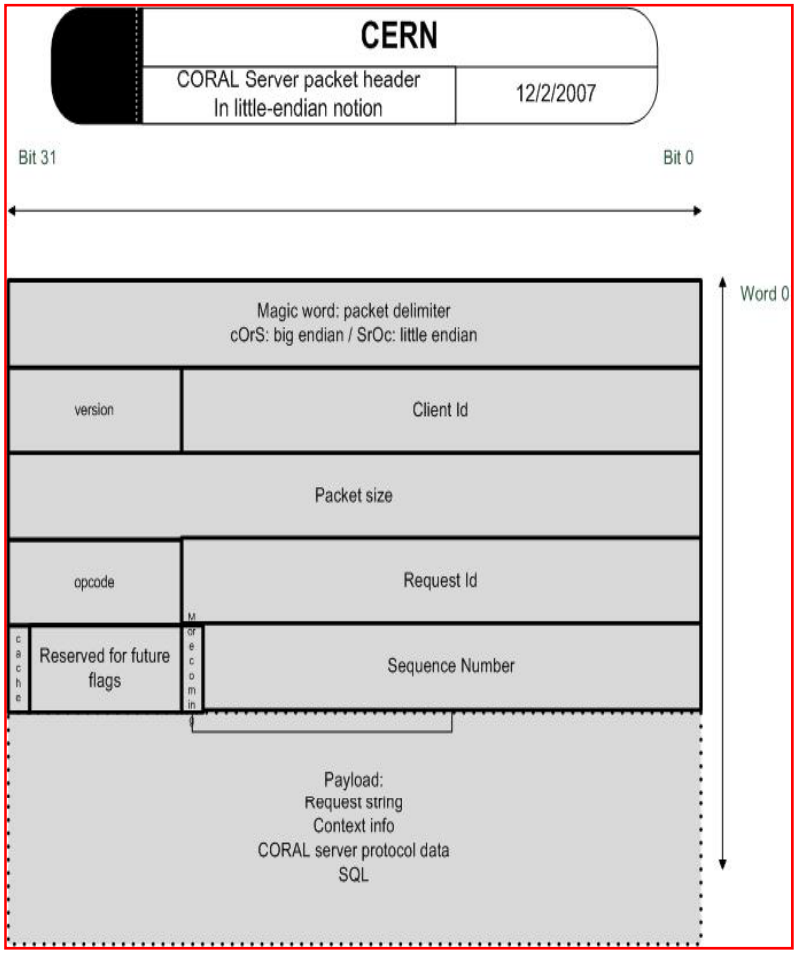
- Proposed team: Martin, Andy
  - Can we use the same components for server/client and proxy?!
  - Any special requirements for chaining of proxies?

- Exchange packets without assuming relational content
  - First header for this package only needs low level TCP/IP protocol
    - endian, version, clientID (for proxy), packet size, requestID (, seq#?)
  - A string payload with relational content should start with a second nested header containing the relational metadata, but this package does not need to be aware of this
    - opcode, cacheable flag (, relational version?) (, sessionID?)
    - followed by relational payload
  - Suggest reordering of packet header to simplify IRequestHandler

Package 2 – sockets (+threads)



~CTL ***~CAL***

[SocketHeader [SocketPayload]]]
= [SocketHeader [RelationalHeader [RelationalPayload]]]

SocketHeader
= (MagicWord | Version | ClientID? | Size | RequestID | Seq#?)

RelationalHeader
= (Version2? | Opcode for ICoralFacade method | Flags)

RelationalPayload
= (streaming of ICoralFacade method arguments)

~CAL

Package 2 – sockets (+threads)

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- User of socket tells the socket:
  - Send this string payload
    - This may encapsulate relational data (relational opcode, cacheable flag, relational payload), but the socket does not need to know that…
- User of socket does not tell the socket:
  - The transport-layer packet metadata assigned by the socket
    - Endianness of socket (? use fixed endianness instead ?)
    - Version of socket protocol header
    - Total size
    - RequestID
    - ClientID (?)
    - Sequence# (not needed?)
  - User of the socket does not need to know the above transport-layer metadata (e.g. for relational processing)

Package 2 – sockets (+threads)

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- Threads in the client
  - Several client threads can use the same ClientSocketMgr
- Threads in the server
  - One main listener thread in the ServerSocketMgr
  - One socket thread per established client socket
  - Several handler threads per socket thread
    - Asynchronous handling of requests on each client socket
    - Each handler has/is an IRequestHandler
    - ServerSocketMgr instantiated from an IRequestHandlerFactory to create handlers (in CORAL Server, all these handlers use same ICoralFacade)
- Eventually: add SSL authentication via certificates
  - Authenticate with the CORAL Server before sending any message
  - Unrelated to remote DB authentication or relational content

Package 2 – sockets (+threads)

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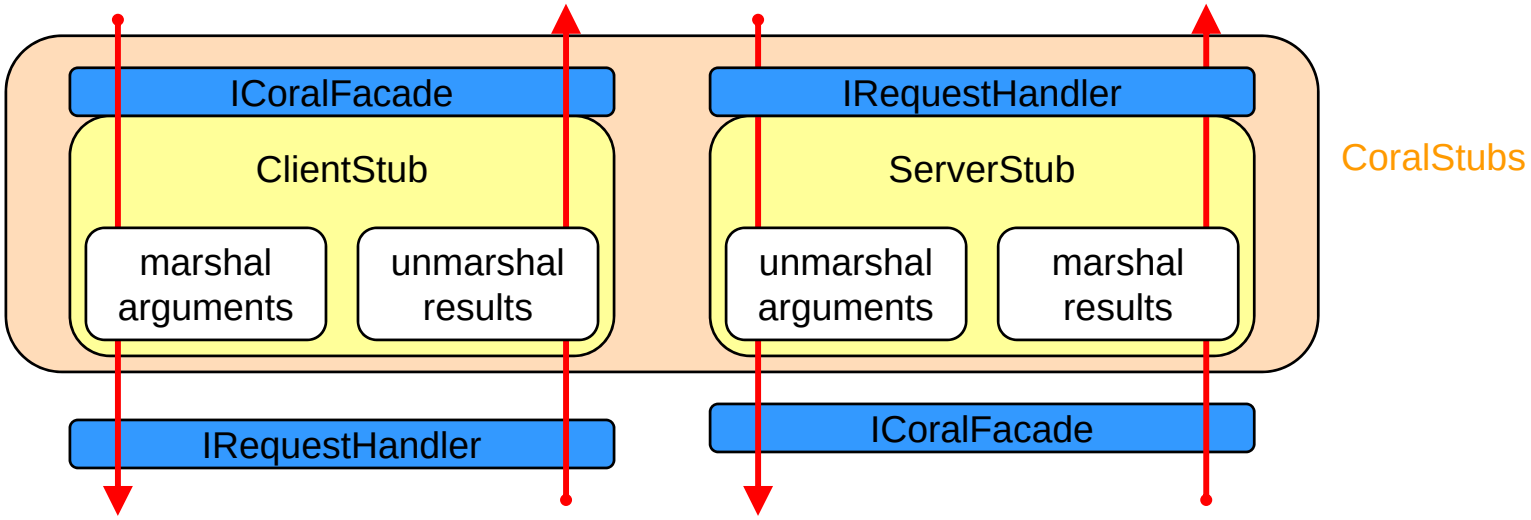
- Standalone tests of the CoralSockets package
  - Use a ‘dummy’ test request handler that returns a reply string which is the same as the request string plus some additional characters
  - Check that the client gets the same results through a local dummy handler or a remote dummy handler connected via sockets
  - Several single and multi client examples:
    - Send all 256 possible characters
    - Send very long strings to check segmentation
    - Send numbered asynchronous requests from several client threads, test that the server sends the right reply to the right client
- Possibilities for reuse of existing code
  - Socket-related state machines
  - Reactor/Acceptor pattern

Package 3 – encoding/decoding

- *In my diagram:* ***CoralStubs***

- Client-side: ClientStub
  - Implements ICoralFacade, delegates to an IRequestHandler
- Server-side: ServerStub
  - Implements IRequestHandler, delegates to an ICoralFacade



Package 3 – encoding/decoding

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- Proposed team: Alex
- Encode as string: relational header plus relational payload
  - Apart from the header, encoding syntax fully encapsulated here
  - System design should avoid need to publish all opcodes
- Exception handling is also part of this package
- Possibilities for reuse of existing code
  - Template-based Boost generator and other encoding mechanisms
  - Exception handling infrastructure

Package 3 – encoding/decoding

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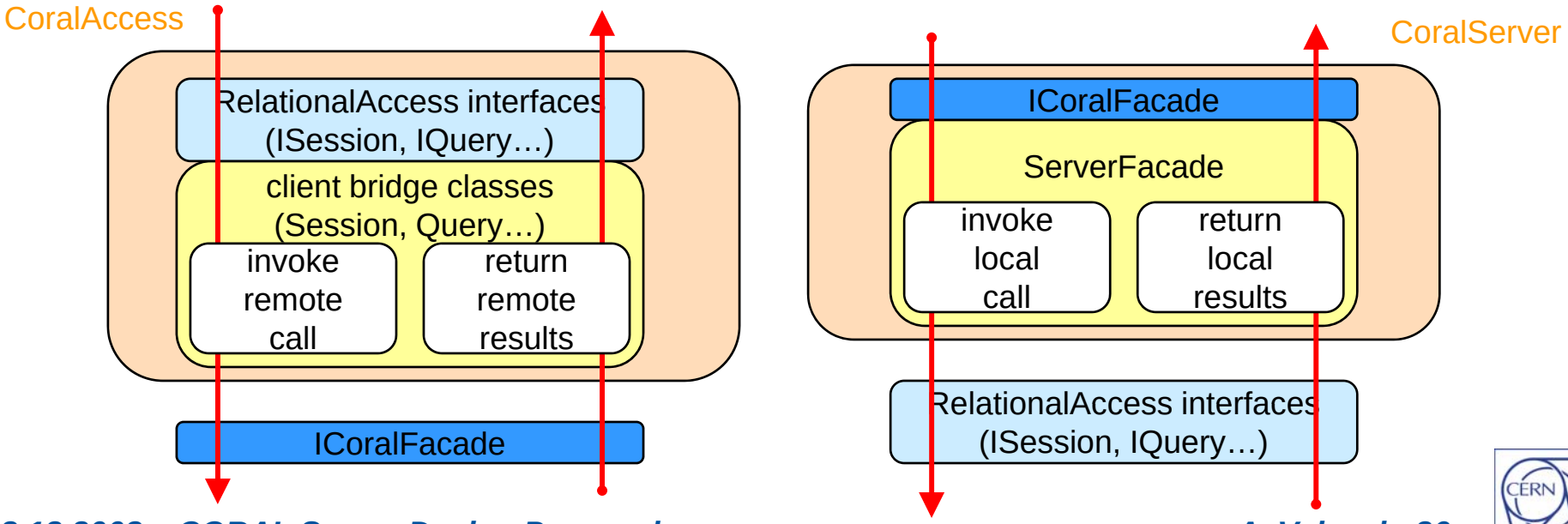
- Standalone tests of the CoralStubs package
  - Process test string, decode, encode back, compare to original
  - Process test arguments, encode, decode back, compare to original
  - Cover also exception throw/catch
  - Cover both requests and replies (unit tests of subcomponents)

Packages 4a/4b – relational access

- *In my diagram:* ***CoralAccess, CoralServer***

- Client-side: bridge classes Session, Query…
  - Implement ISession, IQuery… , delegate to an ICoralFacade
- Server-side: ServerFacade
  - Implements ICoralFacade, delegates to ISession, IQuery…



Packages 4a/4b – relational access

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- Proposed team: Andrea, Alex
- ServerFacade is a CORAL application (ConnectionService)
  - In the general stateful case, an object store registers and looks up sessions, cursors and bulk operations by their token/ID
  - In the stateless case, a single DB session can be opened and no open cursors or bulk operations are allowed
- Remote DB authentication is done by ServerFacade
  - Connection state to remote DB is controlled here

Packages 4a/4b – relational access

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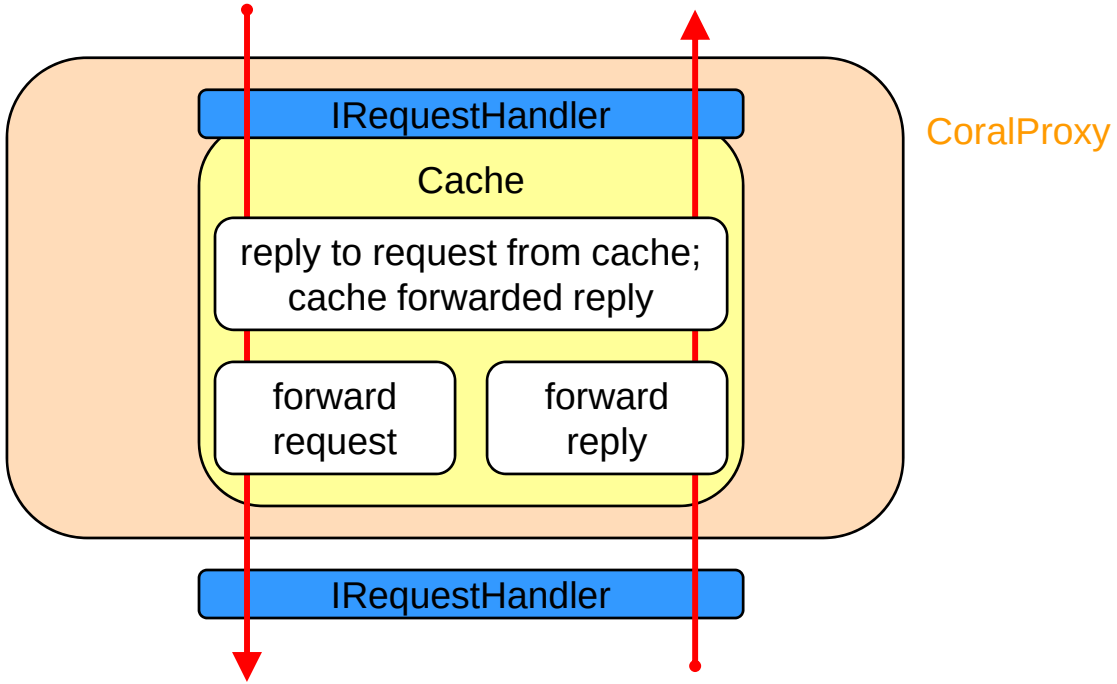
- Standalone tests of the CoralAccess/CoralServer packages
  - Special ‘local’ connection option of CoralAccess: bridge classes delegate directly to a local ServerFacade without encoding/decoding and/or without packet exchange over sockets
  - Load ServerFacade as a plugin if possible to avoid direct linking
  - Any read-only (and eventually read-write) CORAL test can be used
- Possibilities for reuse of existing code
  - Present client code derived from old prototype following this design
  - Resurrect server code from old prototype

Package 5 – proxy cache

- *In my diagram:* ***CoralProxy***

- Proxy cache engine: class Cache
  - Implements IRequestHandler, delegates to an IRequestHandler
  - Filters requests/replies: either reply to requests from cache, or forward them and cache replies for next execution of same request



Package 5 – proxy cache

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- Proposed team: Andy
- Should look at cacheable flag only if possible
  - Which opcodes need a special handling and why?
    - Database connect/disconnect
    - Transaction start/commit/rollback
  - System design should avoid need to publish all opcodes if possible
    - e.g. if startTransaction is a special case of ‘droppable’ packet, add a droppable flag instead, or avoid packet reaching the proxy?
- Any special need for chaining of proxies?

Package 5 – proxy cache

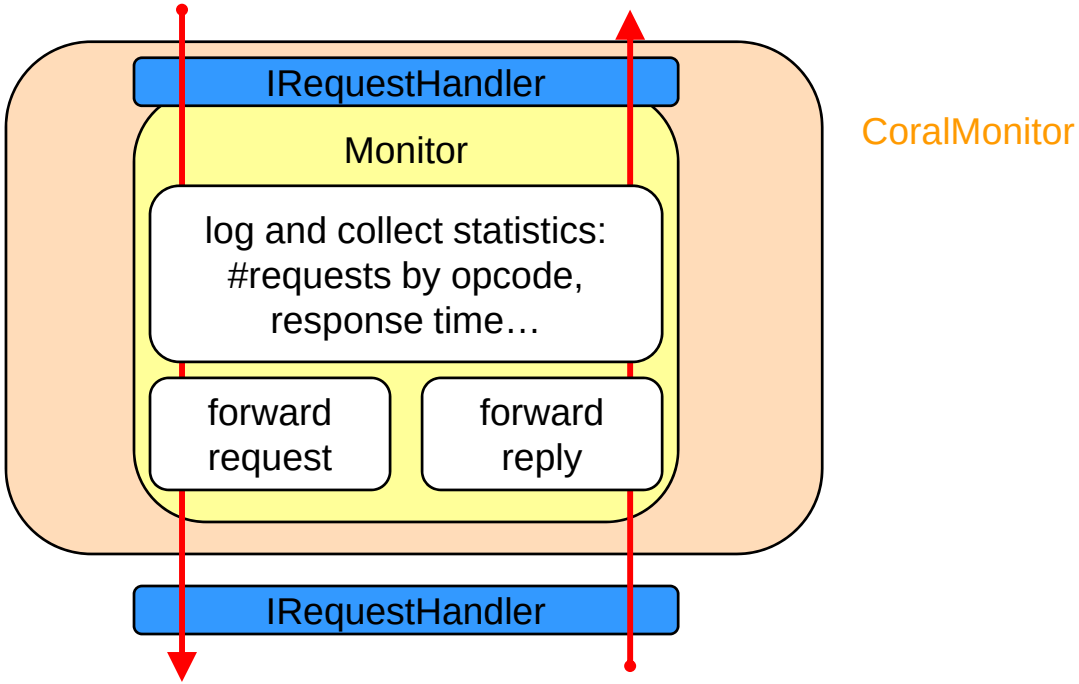
CERN IT Department

- Standalone tests
  - Attach to a test IRequestHandler that always gives different replies to the same request: test that reply from cache does not change after the first time if the cacheable flag is set
- Possibilities for reuse of existing code
  - Internal cache implementation of present proxy

Package 6 – monitoring

- *In my diagram:* ***CoralMonitor***

- Same class for client, server or proxy: Monitor
  - Implements IRequestHandler, delegates to an IRequestHandler
  - Filters requests/replies: logs statistics while forwarding them



Package 6 – monitoring

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- Proposed team: Andy, Alex
- Possibilities for reuse of existing code
  - Requirements and implementation to be based on present proxy
  - Experience and code from present server monitoring tool
- Standalone tests
  - Attach to a test request handler
  - Check (against references) log files for well defined test loads

Package dependencies

- Most libraries depend on CoralServerBase interfaces only
  - All components implement or use ICoralFacade or IRequestHandler
- CoralAccess needs concrete ICoralFacade implementations
  - ClientStub: link CoralStubs and CoralSockets if necessary
  - ServerFacade for tests: load as a plugin if possible
- Tests and executables need concrete implementations
  - Additional CMT dependencies only for tests and executables
  - Executable code can be an extremely simple chain of components
    - ServerSocketMgr(ServerStub(ServerFacade(ConnectionService())))

Intermediate alternatives

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- Keep present proxy as standalone executable
  - More difficult to share a monitoring component
  - Duplication of code in the handling of sockets
- Keep present packet header
  - Add some relational metadata to the IRequestHandler interface