Scaling Erlang Web Applications

100 to 100K users at one web server

Fernando Benavides (*@elbrujohalcon*)

Inaka Labs

March 27, 2012

Hello World!

- I'm a developer since I was 10
- I worked with Visual Basic, C#, .NET, Javascript . . .
- I switched to functional programming in 2008
- I wrote my thesis project in Haskell
- I'm an Erlang developer since then

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Inaka

TODO: Chad's speach for this

Introduction

My talk is on the scalability of a *web* project that has an *HTTP API* and a component that keeps clients *connected* to the server for *long periods* of time.

It's a design pattern seen in many places:

- Chat Rooms
- Social Sites
- Sport Sites

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Scope

We will improve the way we use

- OTP behaviours
- TCP and HTTP connections
- Underlaying system configurations

*We will **not** deal with*

- Multiple machines/nodes
- Database choices and/or implementations

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Match Stream
General Idea

A soccer match is played at some stadium

Match Stream
General Idea

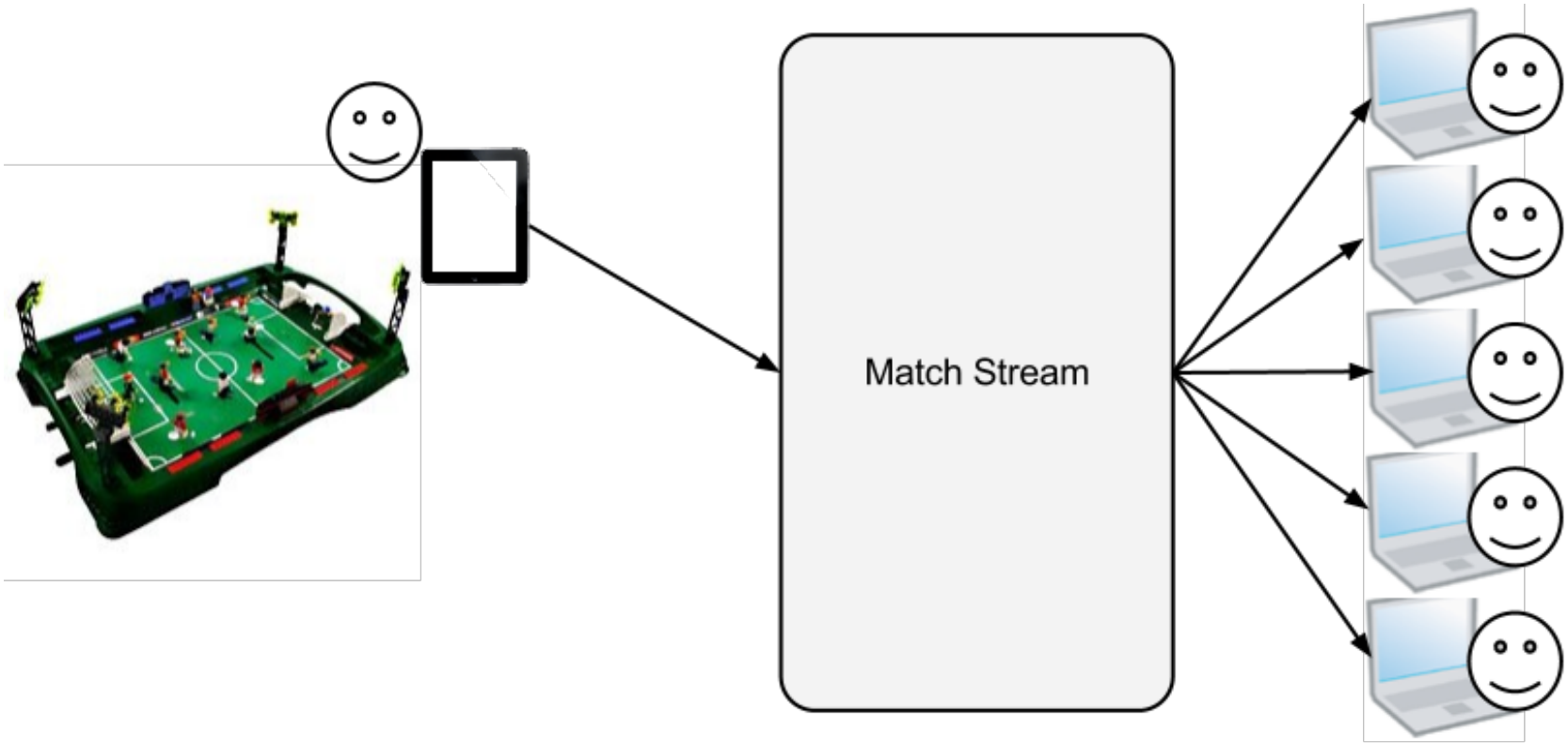
Soccer fans are connected to the internet in their offices

Match Stream
General Idea

A reporter is at the stadium with his device

Match Stream
General Idea

MatchStream ***connects*** *them in* ***real time***



Match Stream
Requirements

System Challenges

- Many concurrent users connecting at the same time
- Two-hour-long bursts of connections followed by long periods of inactivity
- Real-time updates

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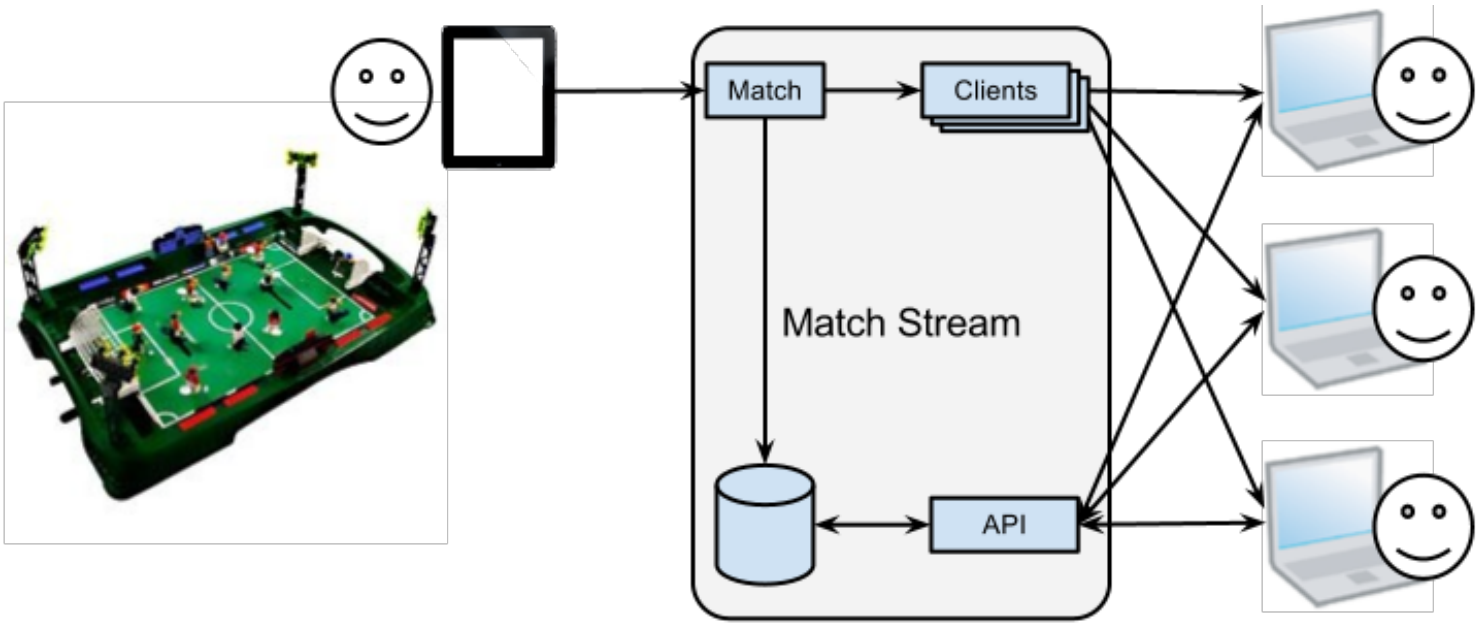
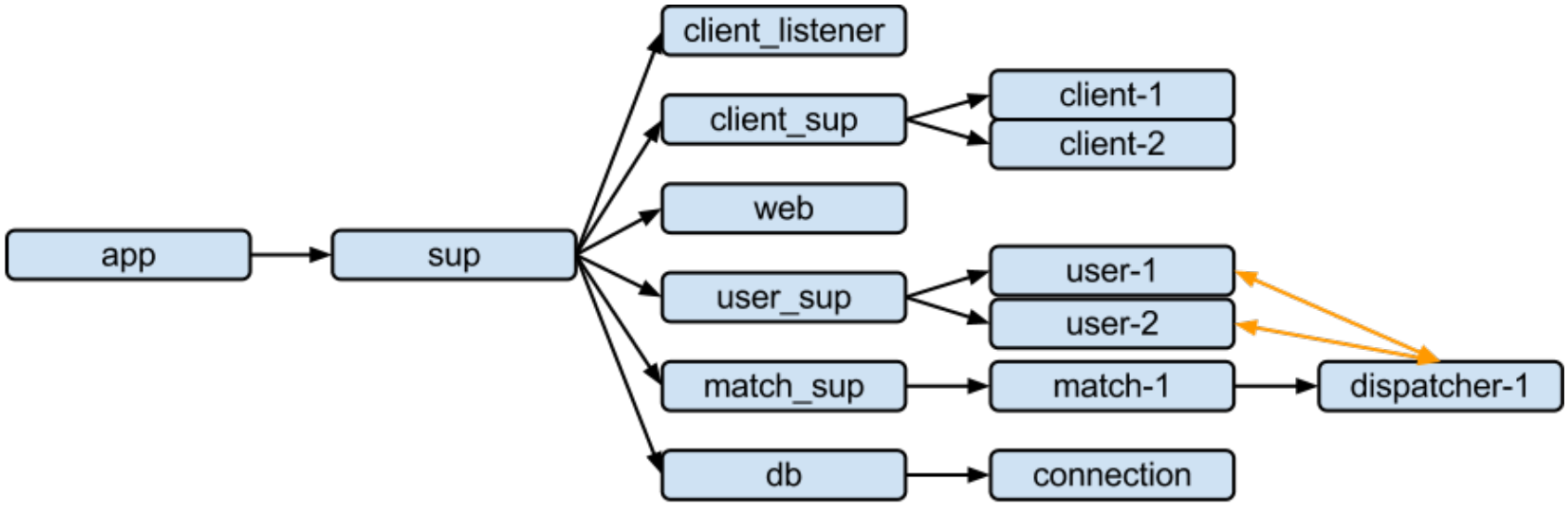
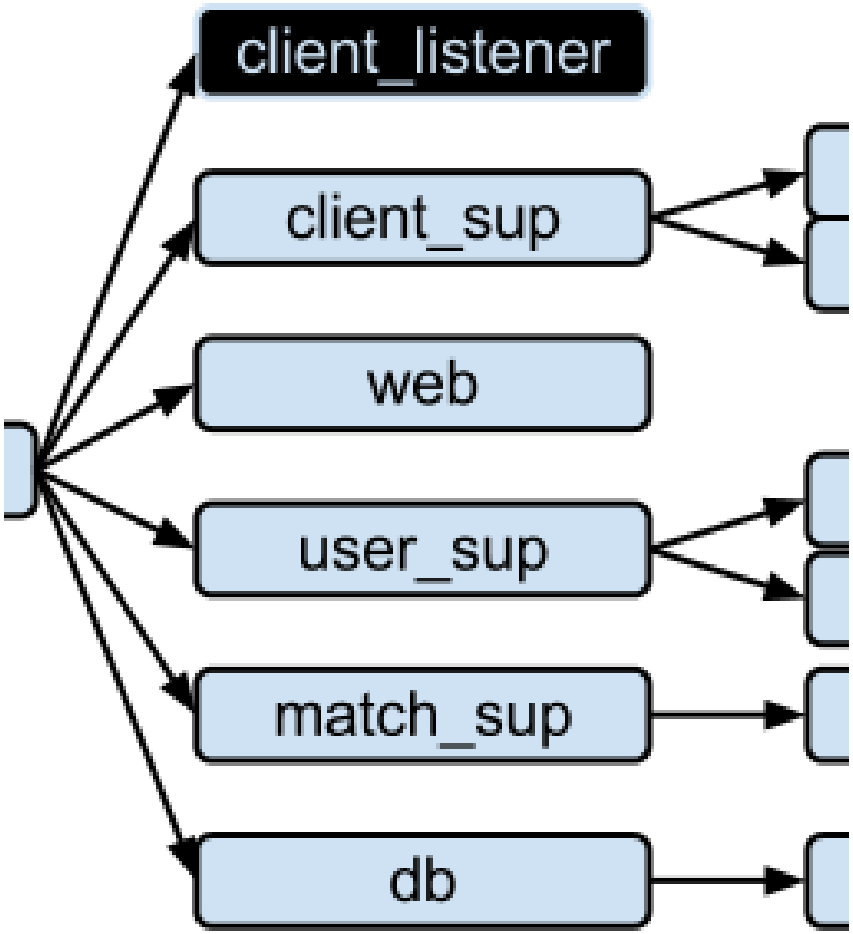
Match Stream
General Design



Match Stream
Architecture



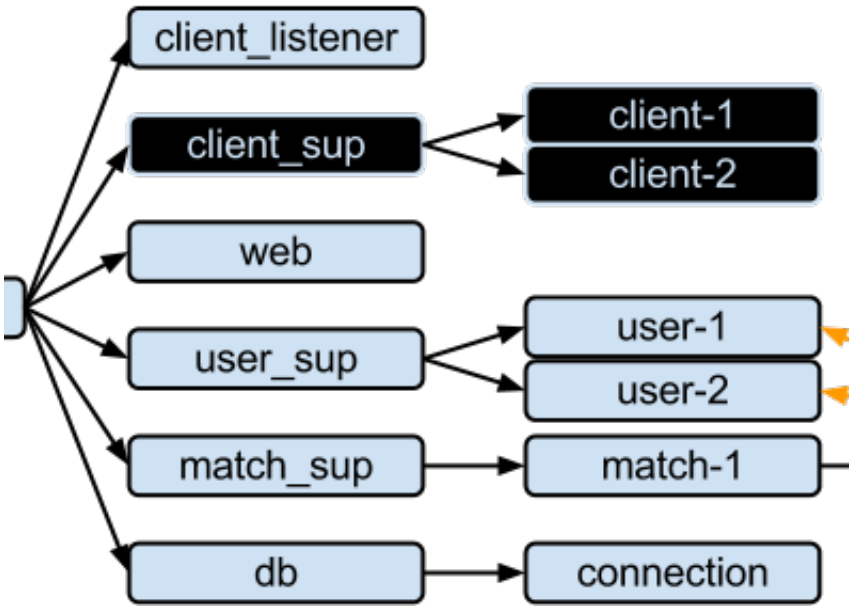
Components



CLIENT_LISTENER `gen_server`.

Listens on a TCP port to receive client connections

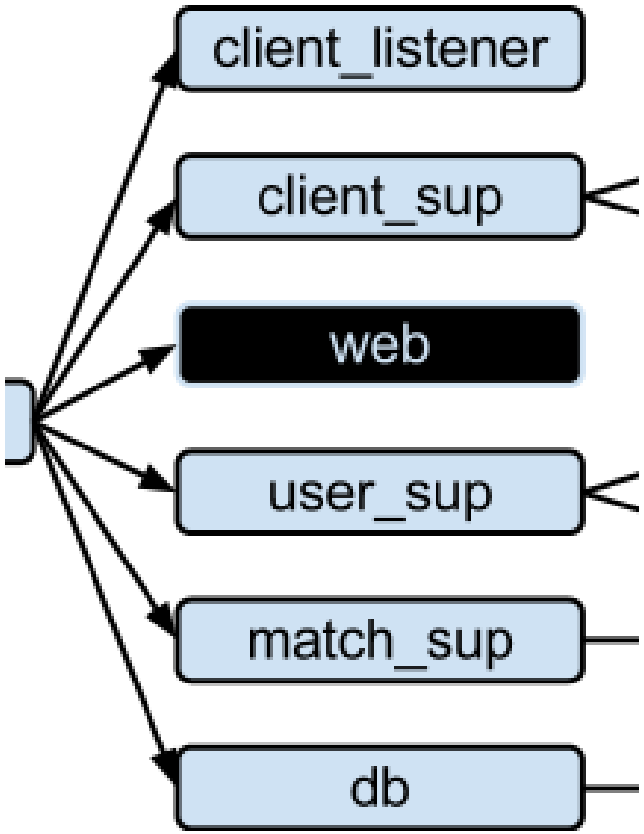
Components



CLIENT_SUP `supervisor.` Supervises connection processes

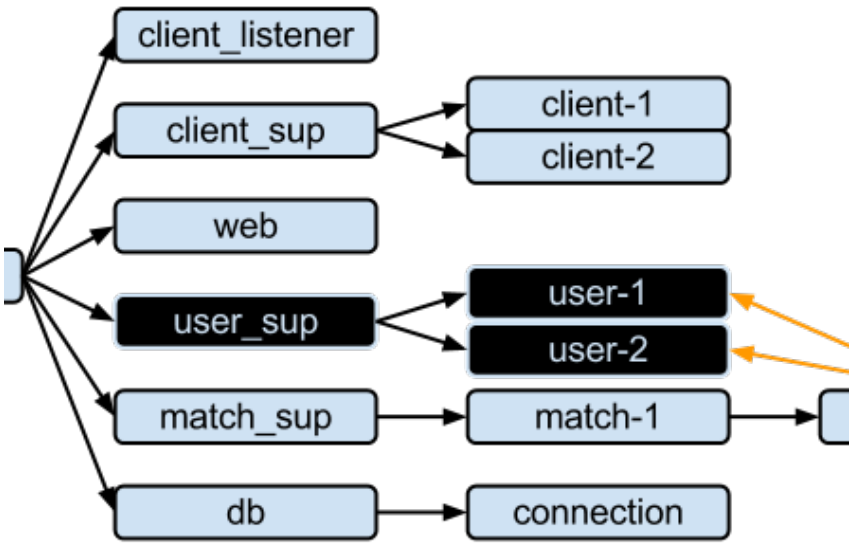
CLIENT `gen_fsm.` Handles a TCP connection

Components



WEB `mochiweb server.`
Listens for HTTP API calls

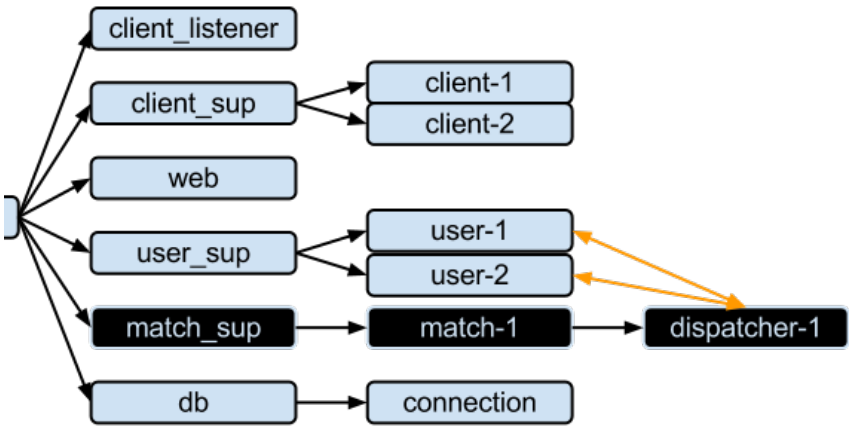
Components



USER_SUP `supervisor`. Supervises user processes

USER `gen_server`. Subscribes to match dispatchers and sends events to clients

Components

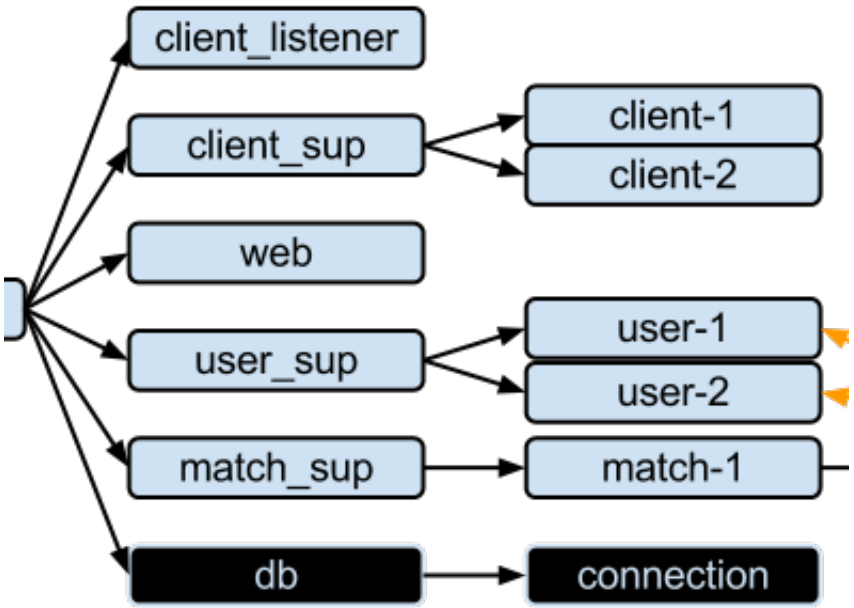


MATCH_SUP `supervisor`. Supervises match processes

MATCH `gen_server`. Listens to match events, stores them

DISPATCHER `gen_event` `dispatcher`. Delivers match events

Components



DB `gen_server`.
Processes database operations

CONNECTION `erldis client`.
Handles the connection to the database

Lesson Learned

*Simply using Erlang to build your system is **not enough** to ensure **scalability***

Measures

N *Connections*. Number of connections the server can handle

C *Concurrency*. Number of multiple connections starting at a time

ART *Average Response Time*. How much does it take for the server to send an event

Tools

Test Client
: We create our own test client for TCP connections

ApacheBench
: To test API calls

entop
: We use it to check server processes

Stage 0
Establishing a Baseline

Goals

- Find how much the system can handle

Steps

- Create automated testers
- Install and start the system on a *clean* machine
- Run the tests on the server's local network
- Test repeatedly adjusting our parameters to maximize them
- Have a human using the system himself

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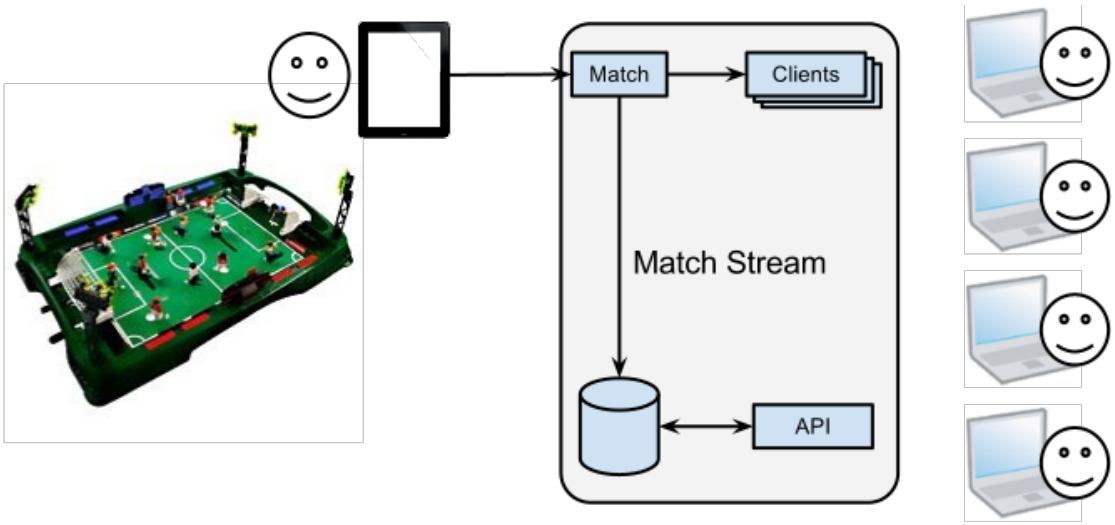
Stage 1
Results



N 1000
C 4
ART 26s

Stage 1
Tune the OS and the VM

Goals

- Improve the underlying Operating System
- Improve the Erlang VM Configuration

Settings to Tune Up

- Open files limit
- TCP connections limit
- TCP backlog size
- TCP memory allocation
- Number of Erlang processes

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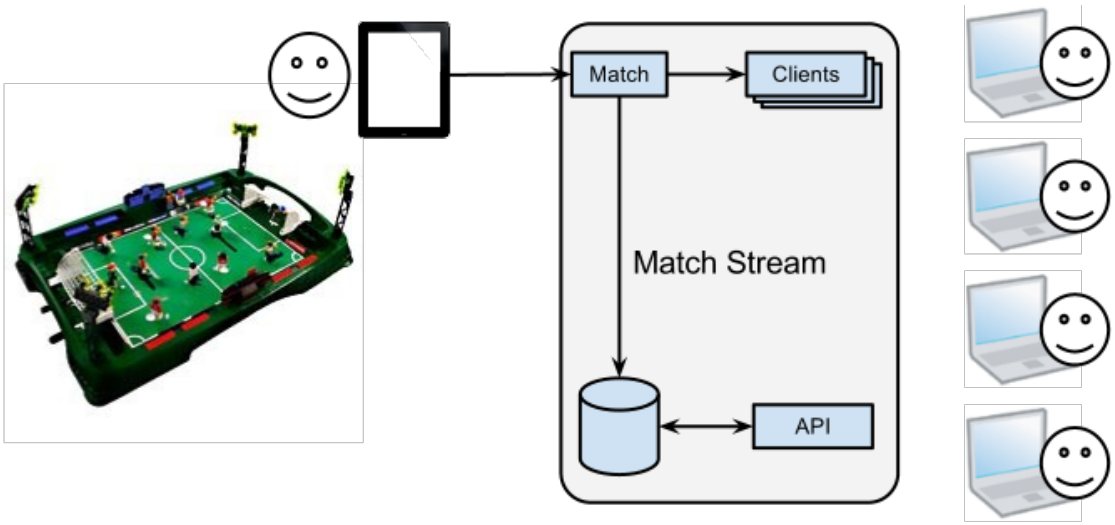


N 4000
C 4
ART 35s

Stage 2
Improving Match Stream

We can't blame the machine anymore, we need to improve our system

Stage 2.1
Connection Tweaks

Backlog

- Allow more concurrent connections
- Don't forget TCP tuning your HTTP server

Stage 2.1
Connection Tweaks

client_listener

```
gen_tcp:listen(Port,
  [binary, {packet, line}, {keepalive, true},
   {active, false}, {reuseaddr, true},
   {backlog, 128000}, {send_timeout, 32000},
   {send_timeout_close, true}]).
```

web

```
mochiweb_http:start(
  [{name, ?MODULE}, {loop, {?MODULE, loop}},
   {backlog, 128000}, {port, Port}]).
```

Stage 2.1
Connection Tweaks

Outbound Connections

- e.g., database connections
- Don't use just one of them
- You may have separated connections for different purposes

Stage 2.1
Connection Tweaks

```
-define(REDIS_CONNECTIONS, 200).
-record(state, {redis :: [pid()]}).
...
init([]) ->
  ...
  Redis =
    lists:map(
      fun(_) ->
        {ok, Conn} = erldis_client:start_link()
        Conn
      end, lists:seq(1, ?REDIS_CONNECTIONS)),
  {ok, #state{redis = Redis}}.
```

Stage 2.1
Connection Tweaks

```
handle_call(Request, From, State) ->
  [RedisConn|Redis] = State#state.redis,
  proc_lib:spawn_link(
    fun() ->
      Res = handle_call(Request, RedisConn),
      gen_server:reply(From, Res)
    end),
  {noreply, State#state{redis =
                          Redis ++ [RedisConn]}}.
```

Stage 2.1
Connection Tweaks

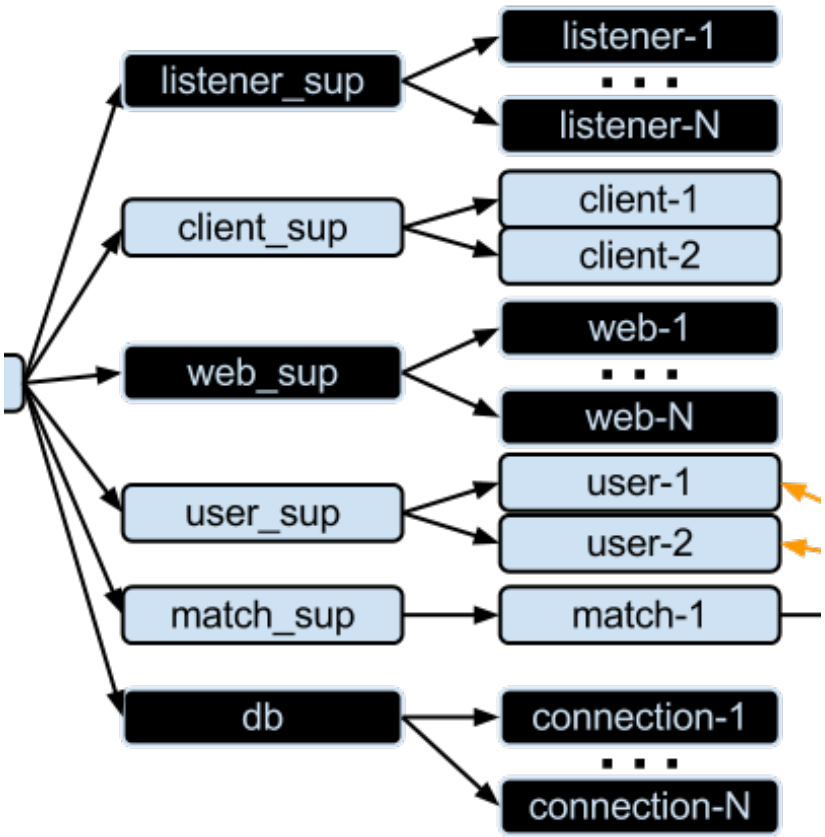
Listeners

- You can listen to more than one port
- For unified urls, use *nginx* in front of the server

Stage 2.1
Connection Tweaks

```
init([]) ->
  ...
  Listeners =
    [{list_to_atom("client-listener-" ++
                   integer_to_list(I)),
      client_listener, start_link, [I],
      permanent, brutal_kill, worker,
      [client_listener]}
     || I <- lists:seq(MinPort, MaxPort)],
  {ok, {{one_for_one, 5, 10}, Listeners}}.
```

Stage 2.1
Connection Tweaks

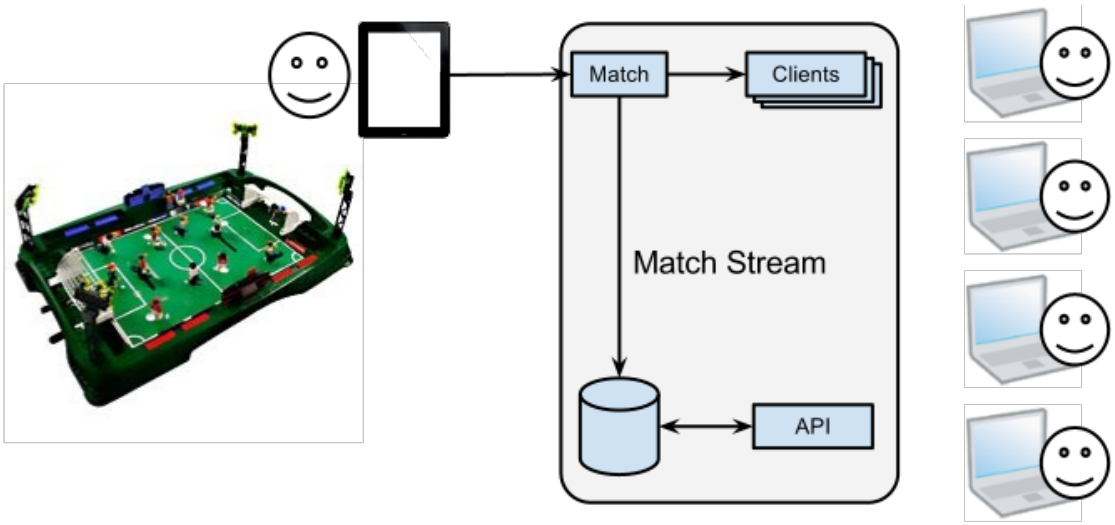


LISTENER `gen_server`. Listens on a TCP port to receive client connections

WEB `mochiweb server`. Listens for HTTP API calls on a particular port

CONNECTION `erldis client`. Handles the connection to the database

Stage 2.1
Results



N **8000**

C **500**

ART **15s**

Stage 2.2

gen_event

sup_handler

- Don't use it
- Monitor the processes instead

Stage 2.2

gen_event

```
EvtMgr =
  match_stream_match:event_manager(MatchId),
ok =
  gen_event:add_handler(EvtMgr,
    {?MODULE, {MatchId,UserId,Client}}, self()),
MgrRef = erlang:monitor(process, EvtMgr),
ClientRef = erlang:monitor(process, Client),
{reply, ok,
 State#state{matches =
  [{Client, MatchId, ClientRef, MgrRef}
   | State#state.matches]}}
```

Stage 2.2

gen_event

```
handle_info({'DOWN',Ref,_,Client,_}, State) ->
  ...
  case lists:keytake(Ref, 4, State#state.matches) of
    {value, {Client,_,CRef,Ref}, OtherMatches} ->
      ...
```

Stage 2.2
gen_event

Long Delivery Queues

- Distribute the work
- Use *repeaters*

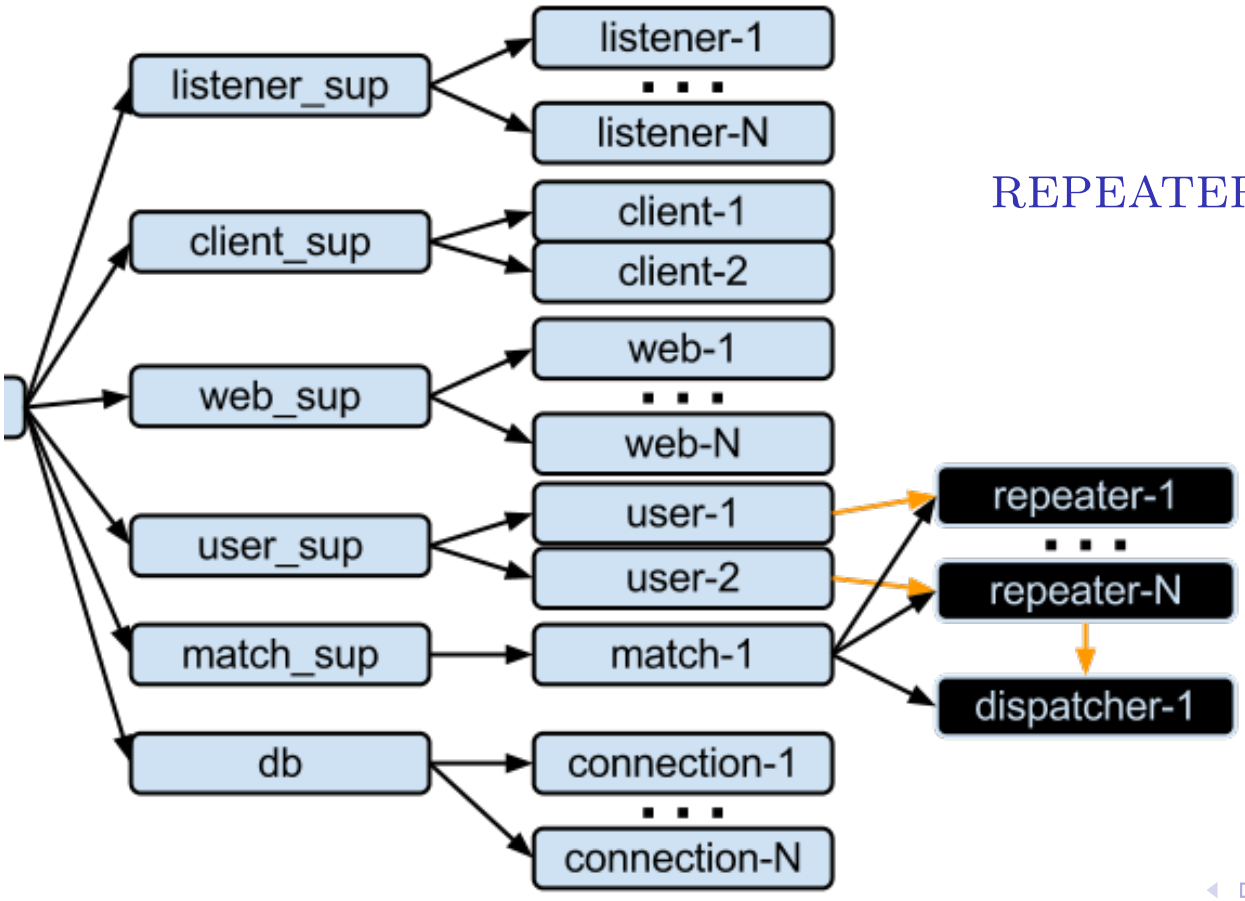
Stage 2.2

gen_event

```
start_link(Name, Source) ->
  {ok, Pid} = gen_event:start_link(Name),
  ok = gen_event:add_handler(
         Source, {?MODULE, Pid}, Pid),
  {ok, Pid}.
...
init(Repeater) ->
  Ref = erlang:monitor(process, Repeater),
  {ok, #state{mgr = Repeater, ref = Ref}}.
...
handle_event(Event, State) ->
  gen_event:notify(State#state.mgr, Event),
  {ok, State}.
```

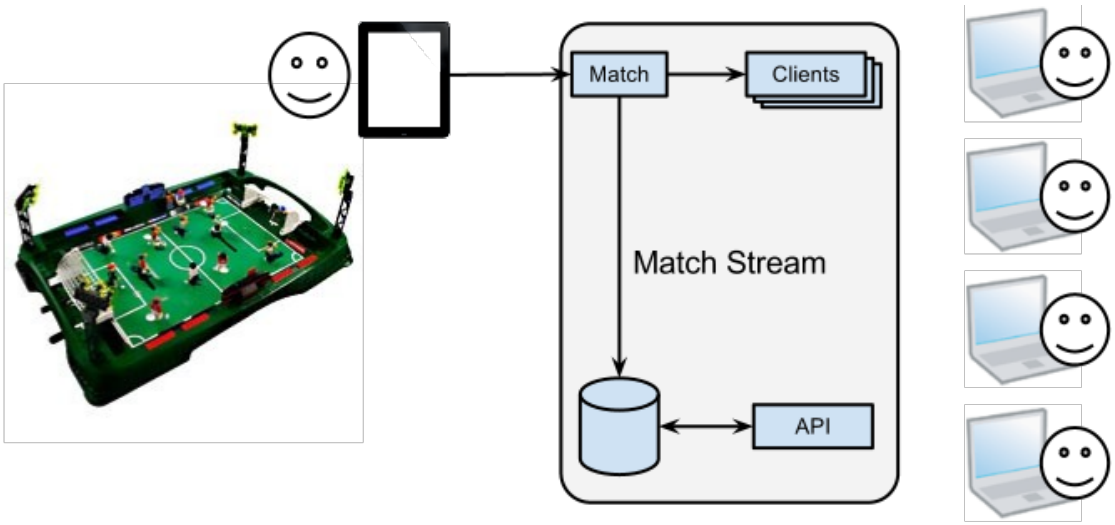
Stage 2.2

gen_event



REPEATER `gen_event` `dispatcher`. It's subscribed to `dispatcher` and *repeats* the received events to its subscribers

Stage 2.2
Results



N 8000

C 1000

ART 2s

Stage 2.3
gen_server

Call Timeouts

Remember `gen_server:reply/2`

Stage 2.3

gen_server

```
handle_call(Request, From, State) ->
  [RedisConn|Redis] = State#state.redis,
  proc_lib:spawn_link(
    fun() ->
      Res = handle_call(Request, RedisConn),
      gen_server:reply(From, Res)
    end),
  {noreply, State#state{redis =
                          Redis ++ [RedisConn]}}.
```

Stage 2.3

gen_server

Memory Footprint

Remember `hibernate`

Puts the calling process into a wait state where its memory allocation has been reduced as much as possible, which is useful if the process does not expect to receive any messages in the near future.

(Erlang Docs)

Stage 2.3

gen_server

```
handle_cast(Event, State) ->
  ...
  {noreply, State, hibernate}.

...

handle_call(Request, _From, State) ->
  ...
  {reply, Reply, State, hibernate}.
```

Stage 2.3
gen_server

Long startup time

- Initialize your gen_servers in a 0 timeout
- Move initialization code to `handle_info`

Stage 2.3

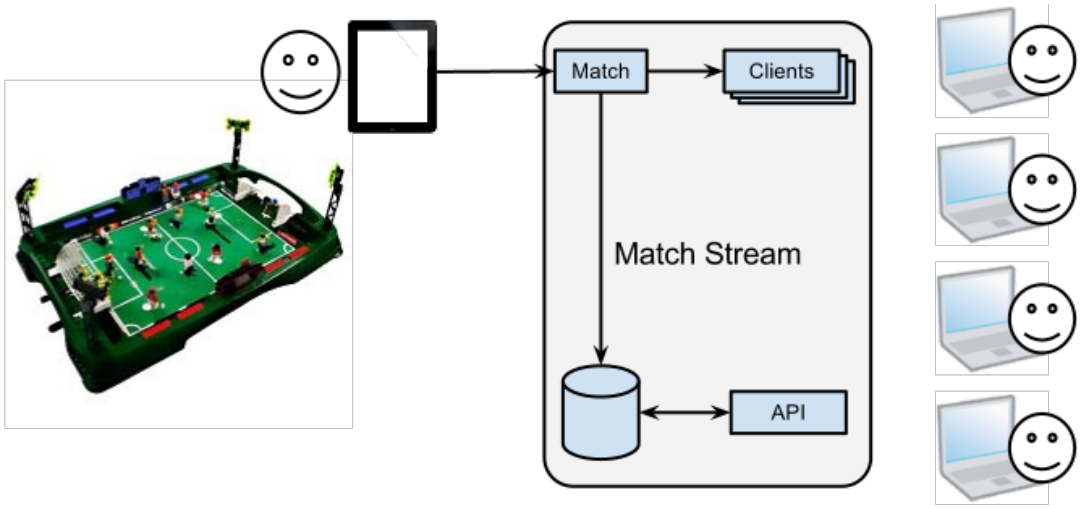
gen_server

```
init(UserId) ->
  {ok, #state{user = UserId}, 0}.

...

handle_info(timeout, State) ->
  case match_stream_db:user(State#state.user) of
  ...
```

Stage 2.3
Results



N **40K**

C **5K**

ART **25ms**

Stage 2.4
supervisors

Simple One for One Supervisors

- Sometimes `simple_one_for_one` supervisors get overburdened because they have too many children
- Use a supervisor hierarchy

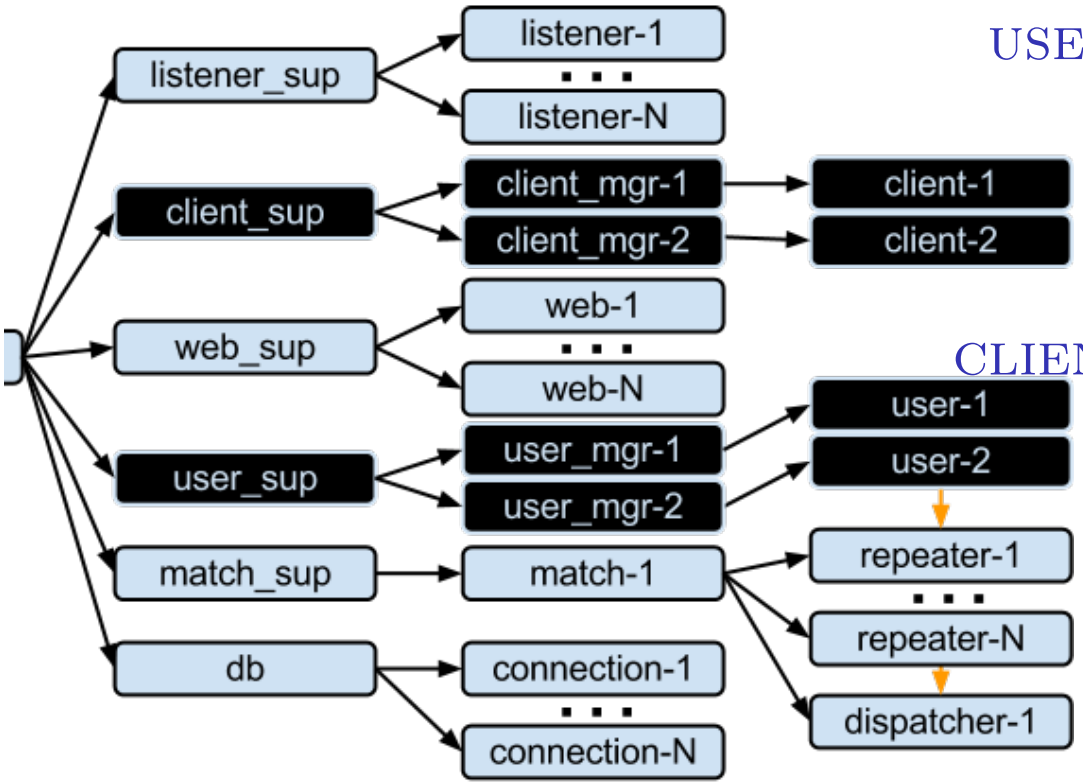
Stage 2.4
supervisors

```
init([]) ->
  _ = random:seed(erlang:now()),
  Managers =
    [{list_to_atom("user-manager-" ++
                   integer_to_list(I)),
      {user_mgr, start_link, [I]},
      permanent, brutal_kill, supervisor,
      [user_mgr]}
     || I <- lists:seq(1, ?MANAGERS)],
  {ok, {{one_for_one, 5, 10}, Managers}}.
```

Stage 2.4
supervisors

```
start_user(User) ->
  Manager =
    list_to_atom(
      "user-manager-" ++
        integer_to_list( random:uniform(?MANAGERS) )),
  supervisor:start_child(Manager, [User]).
```

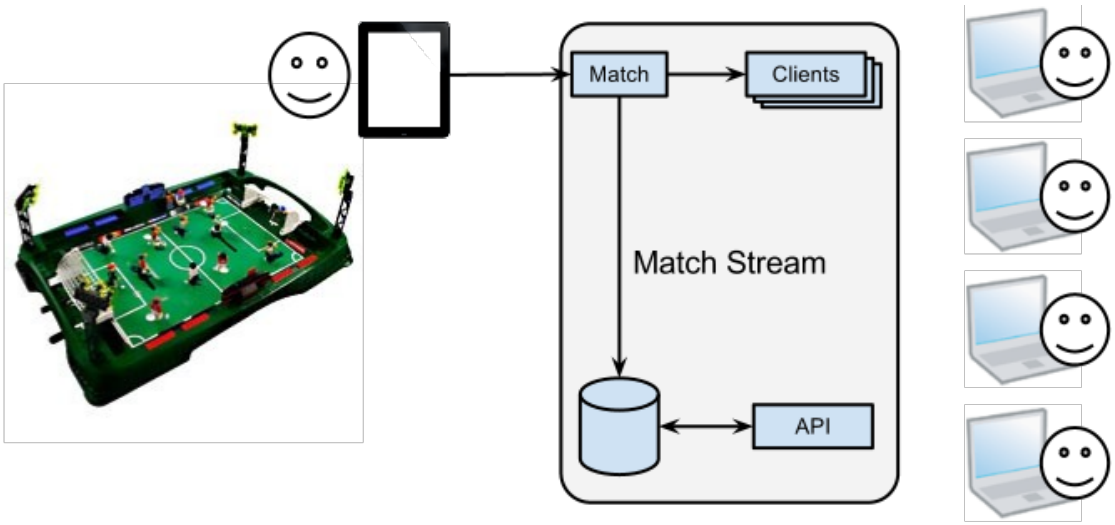
Stage 2.4
supervisors



USER_MGR `supervisor`. Supervises a group of users processes

CLIENT_MGR `supervisor`. Supervises a group of connection processes

Stage 2.4
Results



N **50K**

C **8K**

ART **25ms**

Stage 2.5
Other Processes

Logging

- Use a good logging system
- Choose carefully what to log

Stage 2.5
Other Processes

Registration

- Sometimes it's better to register processes instead of keeping track of their pids manually

TODO: Chad's phrase for this

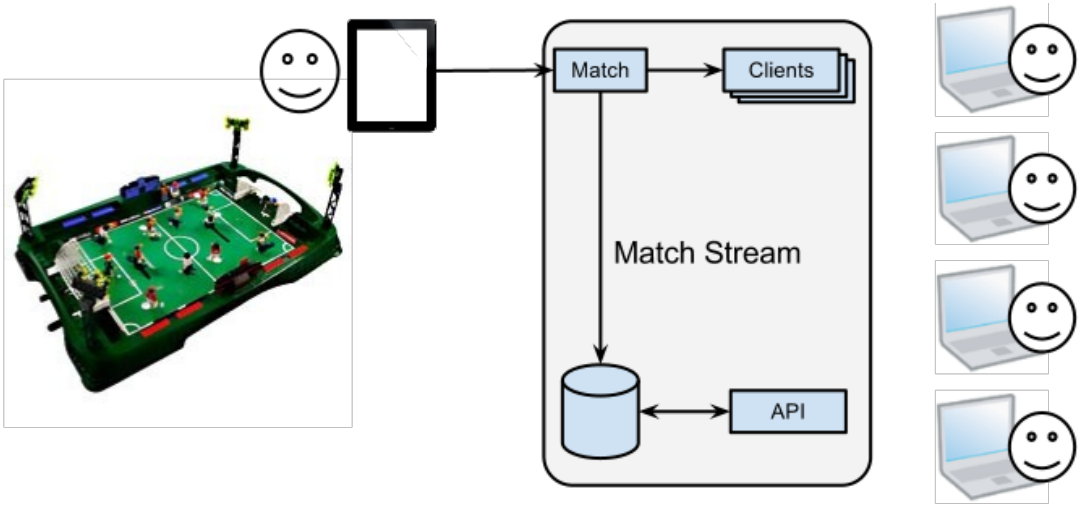
- You can always register processes both locally and globally

Stage 2.5
Other Processes

```
event_manager(MatchId) ->
  binary_to_atom(<<"event_mgr@", MatchId/binary>>, utf8).

init(MatchId) ->
  {ok, EventMgr} =
    gen_event:start_link(
      {local, event_manager(MatchId)}),
  ...
```

Stage 2.5
Results



N **50K**
C **8K**
ART **10ms**

Stage 3
Adding Nodes

Goals

- Find the best system topology

Steps

- Prepare the system to run in more than one node
- Decide if nodes should be connected or independent
- Decide if nodes should be on the same machine or not

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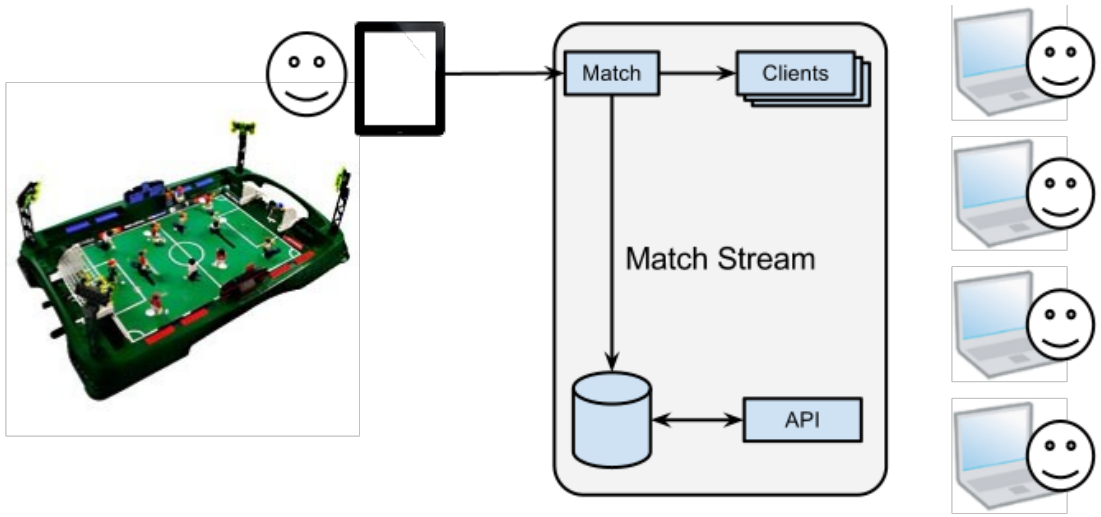
Stage 3
Adding Nodes

TODO: Draw this!

DB_READER `gen_server`. One per node. Processes db read operations

DB_WRITER `gen_server`. One per system. Processes db write operations

Stage 3
Results



With four nodes in the same machine:

N **100K**

C **32K**

ART **10ms**

Summary

With started with:

N **1K**
C **4**
ART **26s**

We scale up to:

N **100K**
C **32K**
ART **10ms**

Our improvements:

N **100x**
C **8000x**
ART **2600x**

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Questions

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