Erlang Factory London 2011
http://www.demonware.net/

Erlang and First-Person Shooters

10s of millions of Call of Duty Black Ops fans loadtest Erlang

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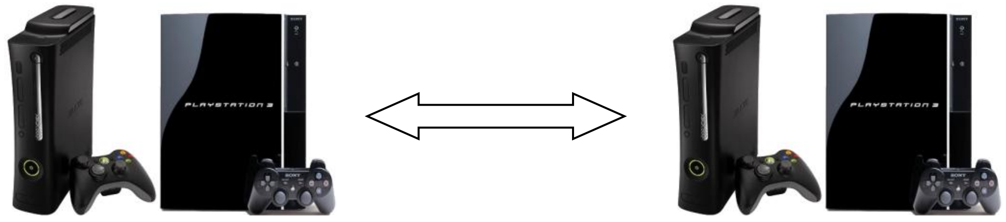
Demonware, Dublin

Overview

- History of Demonware
  - Who are we and what we do?
  - Why we switched to Erlang 4-5 years ago
- Our server-side architecture
  - How we use Erlang now
- What we have learned
  - Mistakes made
  - What we think would be great in the future
  - What we love about Erlang

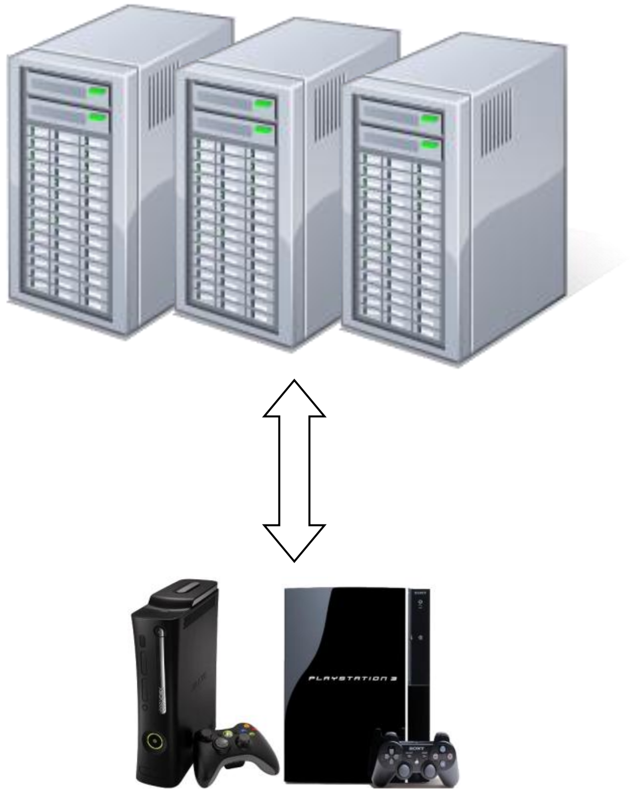
Demonware – What we do

1. Multiplayer
   - Middleware for client-client game state transport
     - Encryption / NAT Traversal
     - Connection management
     - Peer-to-peer / Star topology



Demonware – What we do

2. Lobby servers
   - Matchmaking
   - Leaderboards
   - Stats Storage
   - Messaging/Chat
   - Audio/Video
   - Website Linking
   - Friends/Teams
   - Anti cheat

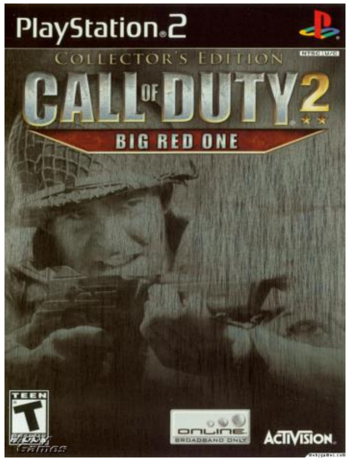


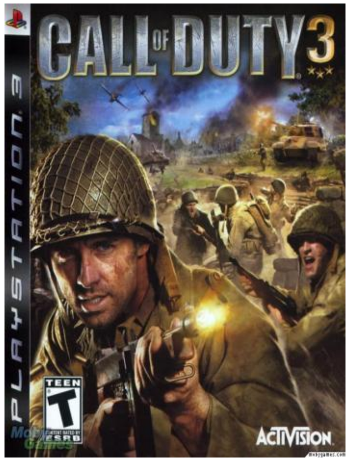
History

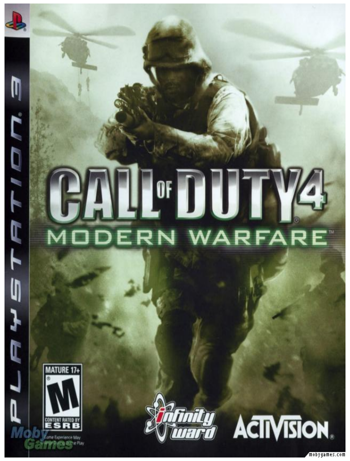
- Founded in 2003 in Dublin
  - Developing middleware for game studios
- In 2005..
  - Started hosting lobby servers
- In 2007..
  - Switched to using Erlang
  - Acquired by Activision (now Activision-Blizzard)
- In 2011..
  - One of the world’s largest online game service providers
  - 60+ employees, Dublin and Vancouver offices

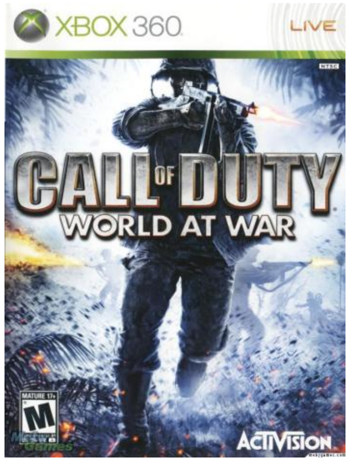
Games that use us

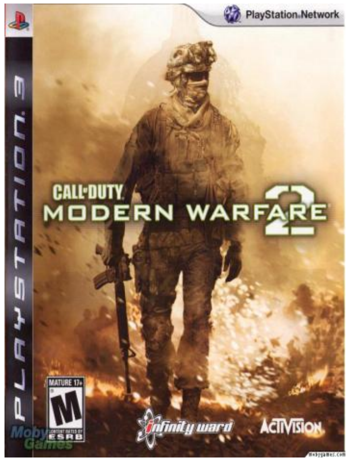
Call of Duty











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Games that use us

…and many more!

What we support

- The full online infrastructure for Call of Duty Black Ops
  - the world's current best selling game.
- Four of the top 10 games on Xbox Live
- Over 2 million concurrent users
  - Comparable in size to Xbox Live
- Over 150 million registered users
- Cross platform:
  - Xbox 360, PS3, Wii, PC, iPhone/iPad
  - Coming soon: 3DS, PSP2

How we got into Erlang

The beginning..

- Mid 2003
  - Founded by former Trinity College Dublin students.
  - Aim: sell client-side networking middleware to games studios.
- Late 2004
  - Lots of polite interest; few customers.
  - Game studios wanted online servers, not middleware.
- Started creating a lobby services platform
  - Xbox 360 had Xbox Live. It set the standard.
  - Games studios needed something for Playstation (and PC)

2005 – C++/C++/Mysql

- Homebrew C++ server
  - Single-threaded
  - Dispatch requests into sub-processes per service
  - Application logic was in C++ and used Mysql
- Problems
  - One OS process per connected user is really bad
    - Max of 80 concurrent users
    - Luckily the first game didn't sell well enough to hit that limit.
  - C++ crashes a lot if code is immature
    - Code was immature.
    - It crashed a lot.

2005/2006 – C++/Python/Mysql

- Rewrote all C++ business logic in Python
  - Maintained a pool of OS processes
- Kept core server in C++
  - Handles 1000s of concurrent connections
  - Encrypts, decrypts, dispatches requests
  - Asynchronous messaging between clients
  - Licenses and duplicate login detection
- Problems remain
  - C++ is the wrong language for concurrency
  - Code was becoming impossible to maintain
  - Poor error handling / debugging / metrics / scalability
  - Had to disconnect all users to change configuration.

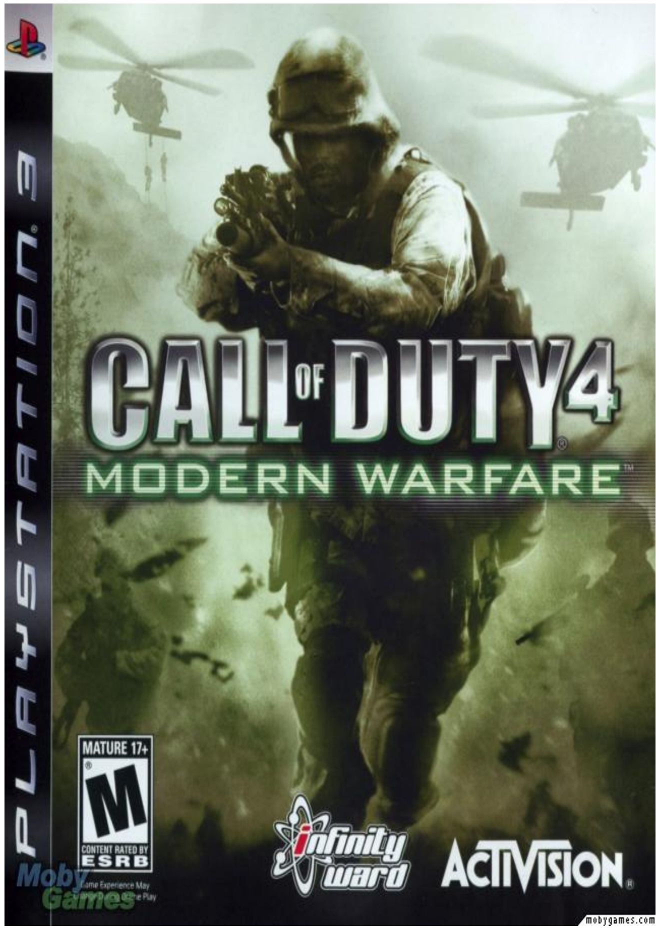
2007 – Erlang/Python/Mysql

- Late 2006 / early 2007.
  - Former developer rewrote the C++ server in Erlang
  - Got a basic prototype running after a few weeks
  - ~4 months of development before used by games studios.
  - Went live for first time in mid-2007
- Improvements
  - Robust: didn’t crash.
  - Easier configuration
    - able to reconfigure everything without affecting clients
  - Better logging and administration tools
  - Faster to develop features, far fewer lines of code

Demonware in 2007

- Lots of customers
  - Activision, Ubisoft, Codemasters, THQ.
  - Acquired by Activision in May.
- Some big games..
  - Splinter Cell Double Agent, Saints Row, Worms Open Warfare, Colin McRae DiRT, Enemy Territory Quake Wars
- But no monster blockbuster
  - 20,000 concurrent users was a big title..
- Still a tiny company
  - 11 devs, 3 ops, 3 managers

Late 2007 – A blockbuster arrives



Late 2007 – A blockbuster arrives

- The most popular game on the (then new) PS3
- Much pain and suffering for us
  - .. and frustration for gamers.
  - Number of users grew continually for 5 months.
  - Every weekend brought a different bottleneck
  - Lots of outages and late nights
- It was a crisis for the company..
  - We had to grow up.
  - Erlang caused us relatively very few issues
  - Without the switch to Erlang the crisis could have been a disaster.

2007 and onwards

- Continual growth
  - In concurrent online users (20k to 2.5 million)
  - In requests per second (500 to 50k)
  - In servers (50 to 1850)
    - Spread across many data centres
  - In staff (17 to 60)
    - Spread evenly between Vancouver and Dublin
  - In competence!
- And many new features/services
  - The Black Ops launch (2010) was colossal
  - Many separate standalone components
  - Erlang/Python/Mysql is the core, but now with many exceptions

How we use Erlang

How we use Erlang

- Our core server for controlling Python
  - Managing 100,000s of concurrent TCP connections
  - Scheduling/queuing of tasks for python
  - Metrics gathering (SNMP)
  - Presence server (fragmented mnesia)
  - Message passing
- Other standalone game-related servers
  - Transient in-game data
  - Testing bandwidth
  - Ranking leaderboards
- In general:
  - for concurrency, and gluing sequential code together

TCP connections / task scheduling

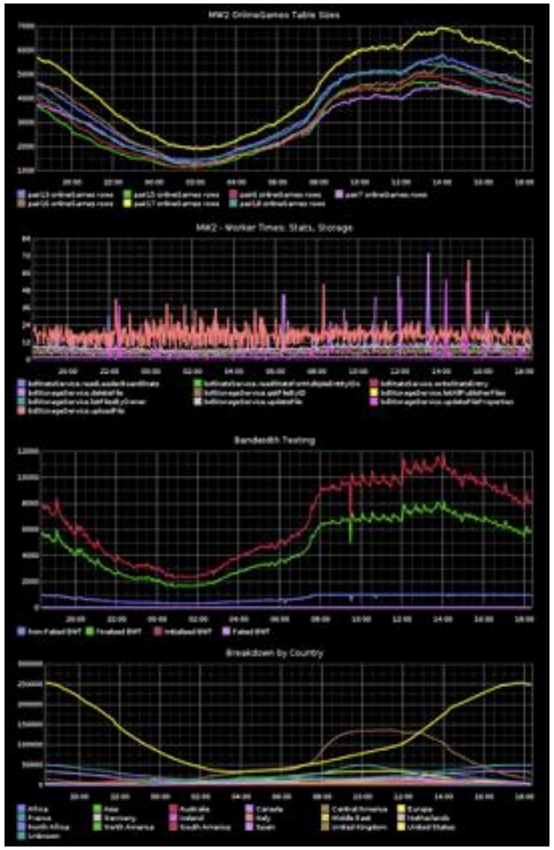
- Two erlang processes per connected user
  - `simple_one_for_one` supervisor
- Delegate work to python OS processes
  - managed by a large supervision tree
  - dedicated task queues for some request types
  - Can restart/update python code without affecting users
- Periodic tasks
  - Use a modified `timer` module.

A presence server

- Needed to
  - Ensure a user can't be logged in twice
  - Prevent duplicate license keys (PC)
  - Provide consistent, distributed snapshot of who is connected
  - In-game messaging
- Use fragmented mnesia
  - Scales linearly
  - Robust
- Our biggest single cluster:
  - 60+ 16-core Dell RC10s

Metrics / SNMP

- The erlang SNMP libraries get good use
- Vital for monitoring
  - online users
  - requests per second
  - request times
  - queue times
  - logins/logouts per second
  - disconnect reasons
- The workhorse is `ets:update_counter`.
- Easy to auto-generate cross-cluster metrics



Configuration

- Each game has a different, often complex configuration
- Our Erlang configuration code allows
  - Complex option settings and validation
  - Defaults, instantiation, inheritance
  - Cross-cluster upgrades
  - Rollback on failure
  - Language agnostic
  - Puppet integration
- Making something configurable should be simple and painless

Webconsole/webservices

- YAWS is used internally
  - Webconsole
    - Live debugging
    - Local development
  - Webservice interface
    - Games studios can remotely
      - Update the message of the day
      - See how popular certain game features are
    - Used by us to control to our clusters remotely

Game-related services

- Leaderboard ranking
  - Keeps huge leaderboards (15m+ users) ranked in real time.
  - Uses ETS and a modified `gb_trees` module.
  - The rank is a feature of the tree itself
- In-memory key-value store
  - Built on ETS.
  - Grouping online users into categories
  - Dynamic chat channels
  - Presence information
- Bandwidth testing
  - UDP packet blast against an erlang server
  - Client gets an estimate of his bandwidth.

Some Lessons we've Learned about Erlang

Lessons: Basics, but important

- Learn to use the core datatypes:
  - Iolists, records (not tuples), binaries/bitstrings, refs, atoms.
- Learn to think functionally + concurrently
  - Tail recursion, functional datastructures, higher-order functions.
  - New processes really *are* that cheap.
- Simple options can go a long, long way
  - Kernelpoll
  - Bind schedulers to cores

Lessons: OTP

- Use OTP religiously
  - Use gen_servers / supervisors
  - Avoid touching `receive` / `!`.
  - Avoid touching `spawn`/`spawn_link`, trap_exit
  - Split reused components into their own OTP applications
- Try to keep modules small, and either
  - Non side-effecting / sequential
  - An OTP behaviour (gen_server, supervisor etc.)

Lessons: KIS(S)

- Avoid..
  - Inter-node dependencies
    - Even though Erlang makes it easy..
    - Avoid having nodes with special responsibilities
    - Expect high latency / inter-node network issues
  - Complex inter-process dependencies
    - Be very afraid of processes which all rely on each other
    - Casts instead of calls.

Lessons: Bottleneck processes

- If a process receives many messages
  - Create a pool of them
  - Make sure they don’t do much intensive work
  - Manually purge message queue?
- If a process does actual work
  - Make sure it’s left alone to do it
  - and it decides when it wants to do more
- Example
  - Logging, metrics.

Lessons: use ETS

- Standard solution to many in-memory storage problems
  - Blisteringly fast
  - Linked to process (automatic cleanup)
  - No monster crashdumps
  - Avoids single-process bottlenecks
- Know its limitations..
  - Try not to reinvent mnesia
  - Distributed copies of ETS tables? Explicit indexes?

Lessons: Use Mnesia... with care

- Extremely powerful
  - Distributed, fragmentation, atomicity, transactional
  - One of the main reasons we moved to Erlang
- But *complex*
  - A lot of subtle, custom code written for error cases
    - Partitioned network; node death; fragment distribution
- mnesia ~= traditional RDBMS?
  - Powerful, fully featured… but so complex, you'll swear and pull your hair out at times.
  - ETS: Simple, fast… but will at times lack the tools you need.

Lessons: Testing/Profiling

- Automated tests
  - Have them, and try to respect them
  - We use `eunit`
  - Make it easy to test a full cluster
  - Rolled our own system for stubbing out modules
- Kill random erlang processes
  - because something else almost certainly will
- Pay attention to the dialyzer and fprof
- Nothing beats heavy-duty end-to-end loadtests
  - Simulate 2 million users!

Lessons: Miscellaneous

- Obvious, but .. keep your clusters apart
  - Different VLANs, cookies
- Beware sharing cores with other OS processes
- Process priorities
  - 10,000 relatively unimportant processes running *slightly* inefficiently will clobber one vital process
- Hot swaps and code replacement:
  - Amazing, but often more effort than it’s worth
- In case things go wrong..
  - Add kill-switches, metrics and graphs for everything
  - Have a collection of helper tools, scripts.
  - Get used to using remote shells

Lessons: Be polite

- Your co-workers don't all care about Erlang like you do
  - Just three/four Erlang developers in Demonware
- Don't force the user of your software to
  - Use Erlang syntax
  - Read Erlang crashdumps
  - Have to understand erlang code
- Either
  - Make them all converts
  - Accept that it's a niche language in the company

Some things we'd love to see in Erlang

Mnesia improvements?

- An Mnesia that lives and breathes network outages and node crashes.
  - Mnesia-Cassandra hybrid?
  - Eventual consistency
  - Automatic rebalancing
  - CAP theorem says there’s no magic bullet.
- Automatic clean up logic
  - Mnesia data divorced from process responsible for it
  - linking of rows to processes/nodes?
  - Distinguishing old and new incarnations of a node.

A neater OTP interface?

- `receive`, `!`, `link`, `spawn` is the Erlang “assembly language”
  - But you have still have to know how it works.
- More flexible supervision trees
  - Hand-crafted dependencies
    - Instead of complex nesting of one_for_one, rest_for_one, etc.
  - Hand-crafted restart strategies
    - Exponential backoffs?
  - Wrap process monitoring too?
- Processes should respond to system messages quickly
  - Writing well-behaved blocking / busy processes is messy
  - gen_background_script?

Easier inter-language integration?

- Erlang isn't a general purpose language
  - It's great for any hard, concurrency problem
  - .. But we would never use it for business logic
  - The ease of concurrency doesn't make up for the difficulty in interfacing with other languages.
  - It's too easy to just muddle through without Erlang
- Make it easy for scripts to be an erlang process
  - Standardise a subset of the protocol.
  - jinterface, twotp, rinterface etc.

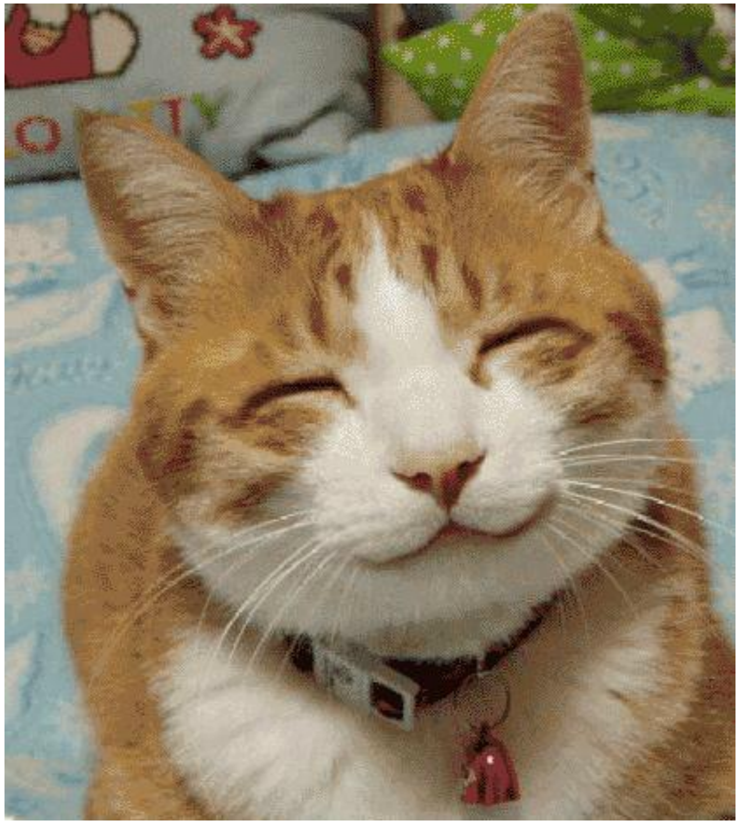
Static Types, Dynamic Hacks?

- A statically typed sub-language
  - A more expressive, less forgiving Dialyzer
  - No side-effecting allowed
    - Confined to modules, helper code that is sequential
  - Being able to enable run-time warnings for dialyzer errors?
- More dynamic features
  - Possible to monkeypatch functions?
  - Easier viewing/modification of running processes.
  - Grotesque hacks *are* sometimes needed.

A Gentler Learning Curve?

- In Erlang
  - (Very) hard things are possible..
  - But (very) easy things still aren’t easy
  - Moving to Erlang is a big commitment
  - Have to first get through the sequential language.
- So, all the usuals
  - Standard guides, coding styles
  - Documentation aimed at non-experts
  - Friendly syntax
- A simple single-step, clustered OTP server?
  - .. easy to understand, and written the right way.

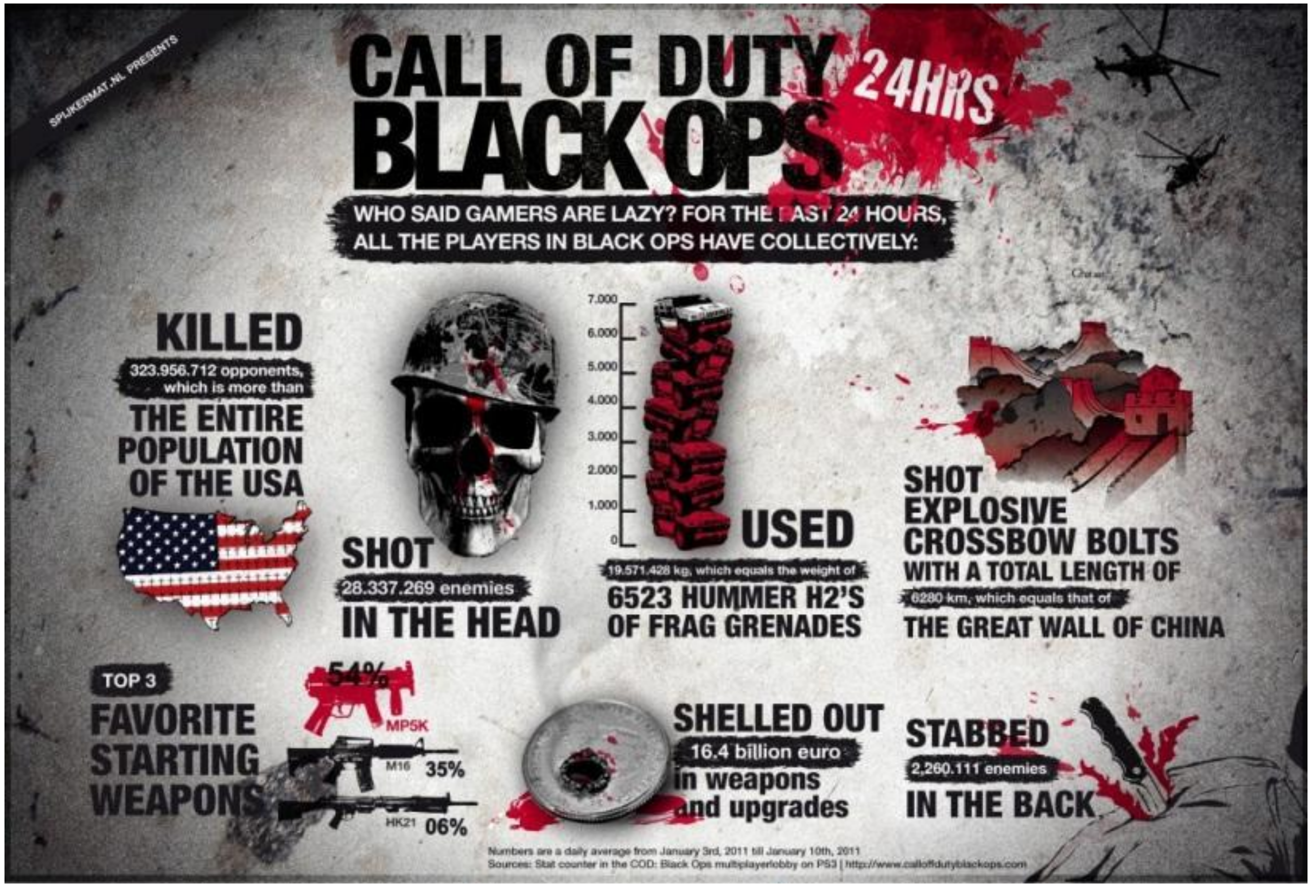
What we love about Erlang



Pretty much everything else..

- But in particular..
  - Effortless concurrency
    - The complete solution for hard concurrent problems.
  - Open source
    - We can look under the hood and play around
  - Remote shells
    - An absolute life-saver.
  - Its sheer robustness and reliability
    - Many months of uptime is par for the course

Black Ops – 24 hour stats


SPIJKERMAT.NL PRESENTS
CALL OF DUTY BLACK OPS 24HRS
WHO SAID GAMERS ARE LAZY? FOR THE LAST 24 HOURS, ALL THE PLAYERS IN BLACK OPS HAVE COLLECTIVELY:
KILLED
323.956.712 opponents, which is more than
THE ENTIRE POPULATION OF THE USA
SHOT
28.337.269 enemies
IN THE HEAD
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0
USED
19.571.428 kg, which equals the weight of
6523 HUMMER H2'S OF FRAG GRENADES
SHOT EXPLOSIVE CROSSBOW BOLTS WITH A TOTAL LENGTH OF
6280 km, which equals that of
THE GREAT WALL OF CHINA
TOP 3
FAVORITE STARTING WEAPONS
54%
MP5K
M16 35%
HK21 06%
SHELLED OUT
16.4 billion euro
in weapons and upgrades
STABBED
2,260.111 enemies
IN THE BACK
Numbers are a daily average from January 3rd, 2011 till January 10th, 2011
Sources: Stat counter in the COD: Black Ops multiplayerlobby on PS3 | http://www.callofdutyblackops.com

In short

- Erlang helps make 10s of millions of gamers happier across the world
- In Demonware, if gamers are happy then so are we.

In short

DemonWare ♥ ERLANG

And finally..

We’re hiring!

See http://www.demonware.net for details

Thanks for listening - any questions?