FROM STRUGGLE TO REDEMPTION

BUILDING THE CHAT SERVICE FOR LEAGUE OF LEGENDS

CHRISTOPHER "LIMA BEANS" MCARTHUR
SENIOR ENGINEER AT RIOT GAMES

RIOT GAMES

LEAGUE OF LEGENDS

LEAGUE OF LEGENDS
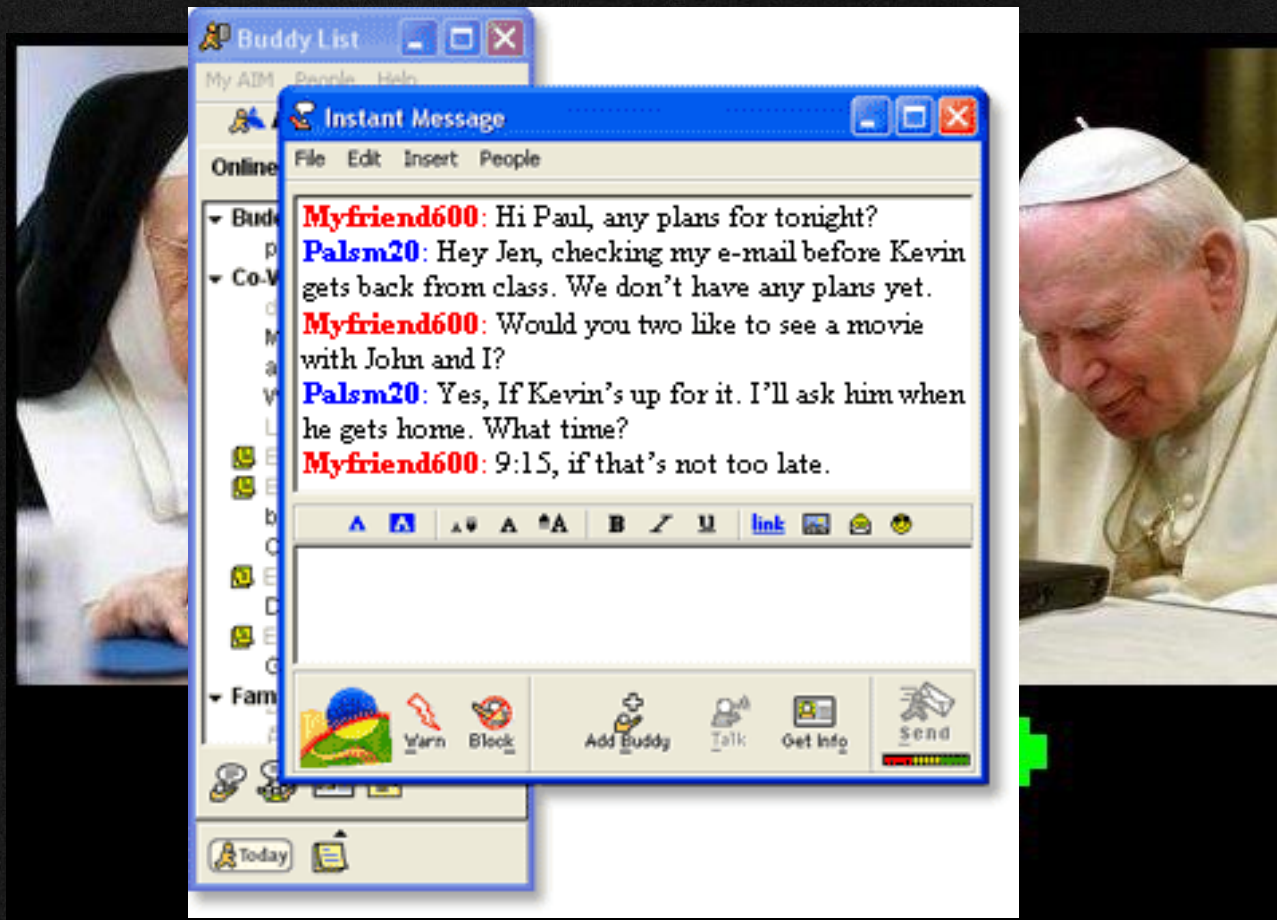
LEAGUE OF LEGENDS

NORTH AMERICA AND EUROPE

15M registered players

4M monthly active players

1.4M daily unique players

500k peak concurrent players

WHY JUST CHAT?

WHY JUST CHAT?

A LITTLE HISTORY

We have a pretty fun game!

But no platform ☹

August 2008: First line of code is checked in.

12 MONTHS

TO BUILD AN ENTIRE ONLINE SERVICE?!?!?
WITH NO BACKEND TEAM!

MISSION IMPOSSIBLE

GDC ONLINE 2011

PROGRESS!

January 2009 – 1000 CCU Scale Test

PROGRESS

April 2009 – Public Beta Begins

October 2009 – Launch!

7 core team members

A small army of contractors

TECHNOLOGIES USED

Backend

— XMPP standard http://xmpp.org/

— EjabberD – Open Source Chat Implementation http://www.ejabberd.im/

— Erlang – Language EjabberD is written in

— MySQL - database

TECHNOLOGIES USED

Frontend

- – Adobe AIR -- Standalone Flash runtime

- – Adobe Flex – Open-source application framework

- – Adobe LCDS – communication layer with server.

- – Xiff – open-source xmpp actionscript implementation http://www.igniterealtime.org/projects/xiff/

HARDWARE MAP

PLATFORM

MySQL

EjabberD Nodes
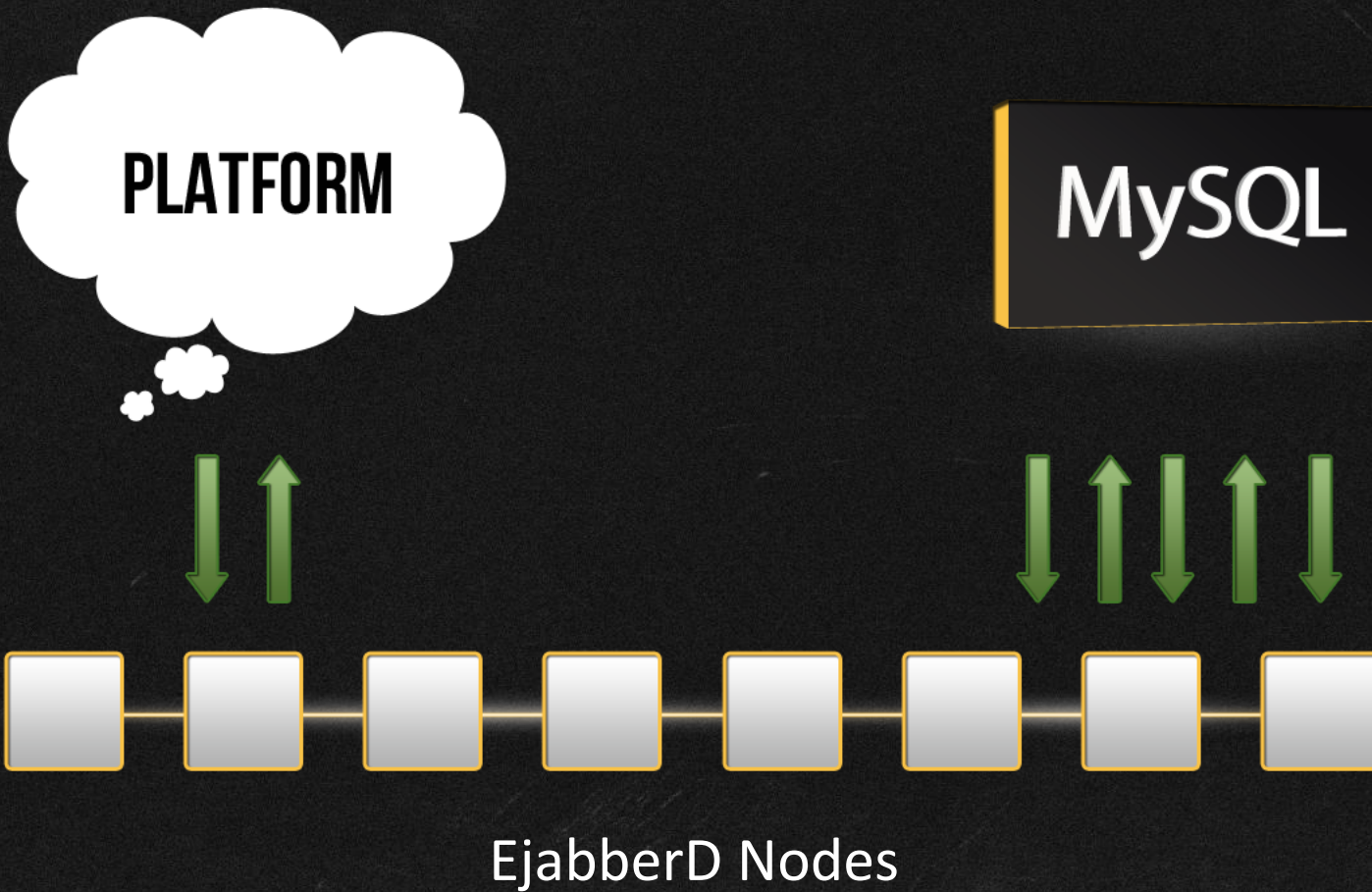
WHY OPEN SOURCE?

Only One Year to Build this!

Many systems to build!

Proven. Scalable. It Works.

XMPP standard used EVERYWHERE.

"RELEASE EARLY
RELEASE OFTEN"

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LITTLE DID WE KNOW....

NOW THE HARD WORK REALLY BEGINS!

4 MAJOR PROBLEMS

~~Get Service Functional Quickly!~~

1) UI

2) Whole Service Instability

3) Did Not Scale
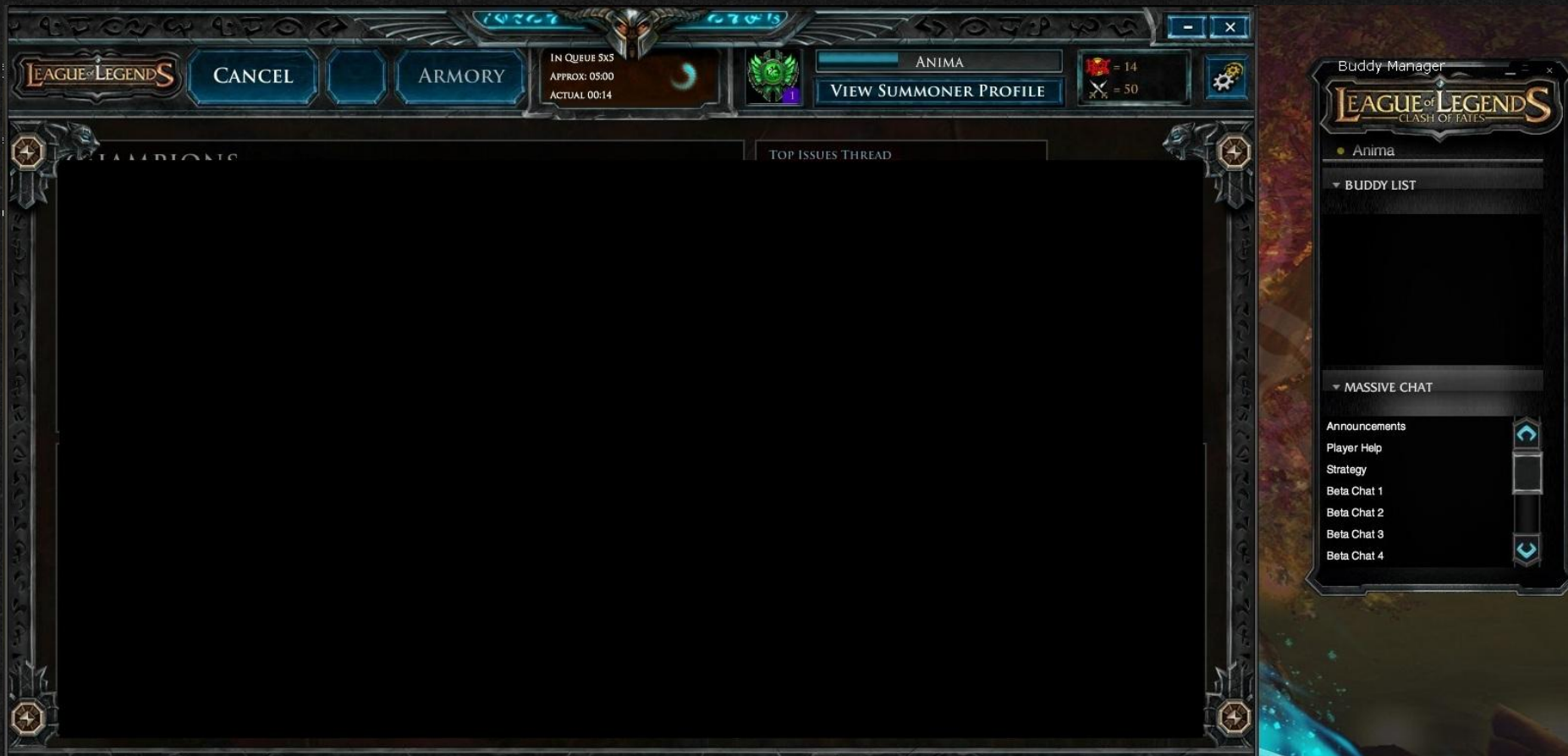
4) Security

(Bonus: Some cool things that worked out!)

PROBLEM 1 -
UI

Initial Naïve Chat Implementation

Separate Floating Windows.

Like a "real" chat client!

FLOATING CHAT

FLOATING CHAT
HATED BY USERS

Why?

Chat Client: Passive, in the Background.

Game Chat: Highly Focused, Highly Active.

CHAT UI
VERSION 2

Looked to Social Media for Inspiration.

Integrated Solution

Tightly tied to game loop.

INTEGRATED CHAT

ITERATION
JUST 2 WEEKS TO ROLL OUT NEW VERSION

No Major Art Commitment yet

Adobe Flex Framework

Model View Controller design pattern.

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MODEL VIEW CONTROLLER

Model

Controller

online:Bool

BuddyList:

Ignorelist

SendMessage();   Login();

AddBuddy();   Logout();

RemoveBuddy

View

tony: hi!

tony 🟢
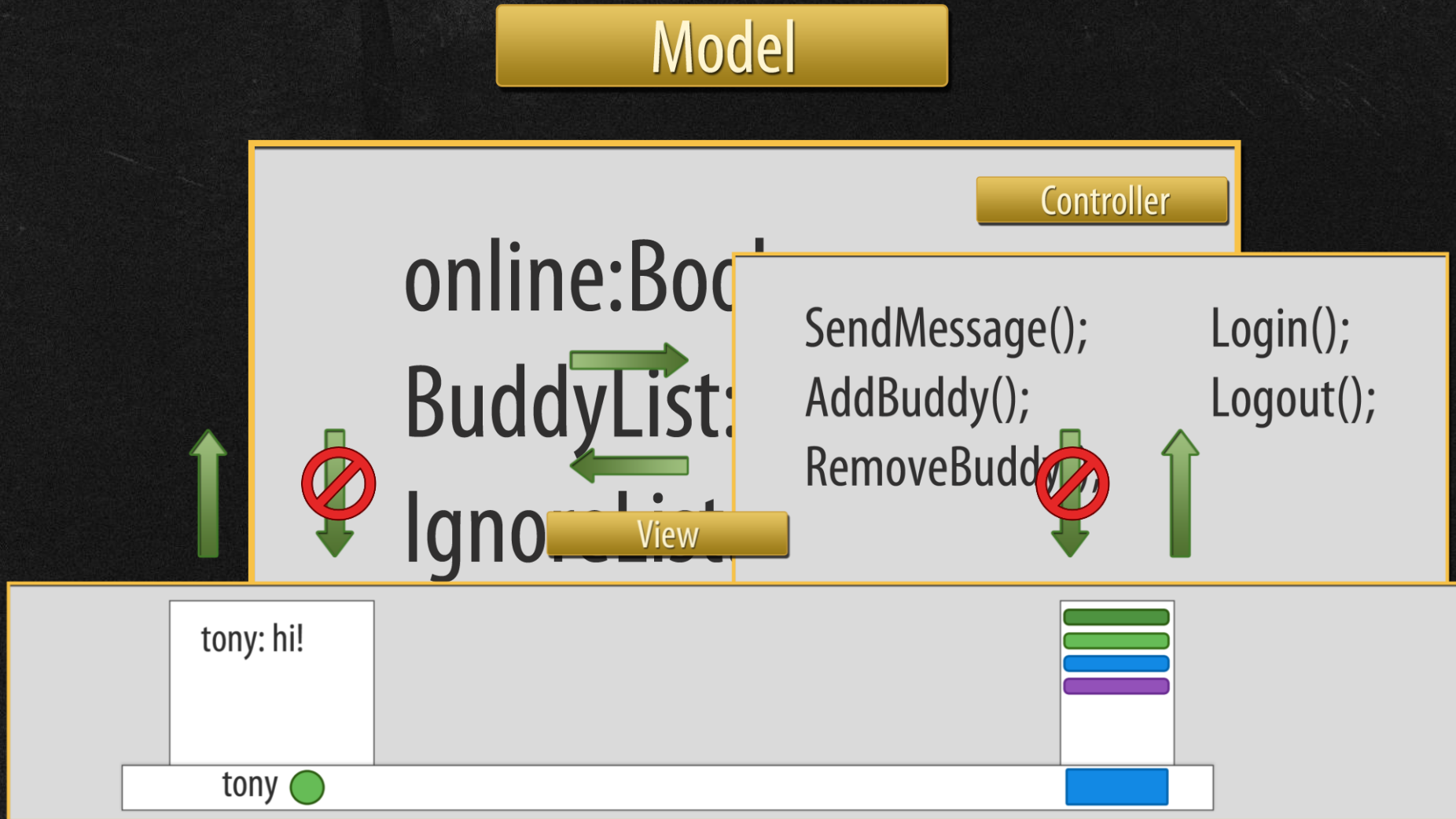
CHAT ROOMS

What Didn't Work:

- Early Complaint: Hard to Make Friends.
- Early Complaint: Service Feels "Empty"

"Traditional" Chat rooms never took off.

League of Legends 1.45.11_10_04_15_28

Overview | Grid | Graph

The Crystal Scar
Dominion
Normal
16:59

VICTORY

IP(+204) +33 +150 +19 +33

Level 30

1 Available

6   3

133 🟢 🔴 0

		⚔	🔥	💰	🏛	🏰	◈
18	bobbyhankhill Annie	12/7/8			3	2	1038
17	Lima Beans Kassadin	6/8/6			7	4	1033
18	JesusJoint Xerath	10/6/8			3	2	989
17	Cycrum Tryndamere	7/8/5			5	4	977
17	Temujinz Singed	4/6/8			2	3	653
18	Kagehane Warwick	14/7/6			6	4	1102
15	UglyPete Riven	7/7/4			5	3	899
17	Shruikhan Kog'Maw	3/10/10			4	5	801
16	raymoaned Jax	6/8/6			5	3	760
18	arkdin Heimerdinger	5/7/11			3	2	694

Your Team
Lima Beans
Temujinz
JesusJoint
bobbyhankhill
Cycrum

Enemy Team
UglyPete
Kagehane
Shruikhan
arkdin
raymoaned

Kagehane joined the room.
arkdin joined the room.
JesusJoint joined the room.
raymoaned joined the room.
Cycrum joined the room.
Temujinz joined the room.
bobbyhankhill: and
bobbyhankhill: i came in at 1
Lima Beans: GG well played
bobbyhankhill: sup

Send

Home | Play Again!

bobbyhankhill ● ✕

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Riot GAMES

League of Legends 1.45.11_10_05_18_28

LEAGUE OF LEGENDS

Play

Lima Beans   755411   903820

30

NEWS

ON SALE ITEM

Acolyte Lee Sin

487

UNLOCK

Lima Beans

Double Rainbow?!?!?!?

Public Chat

Strategy
Users: (0)

Noob
Users: (0)

Looking For Group
Users: (0)

Public Chat 1
Users: (0)

Noob | **Users: (36)**

KangStyle joined the room.
Trilole joined the room.
KangStyle joined the room.
XstreeemNoob joined the room.
battlefie44 joined the room.
The McClure joined the room.
Lima Beans: hellooooooooo
Tagtraum joined the room.
Lima Beans: ?
Epheistos joined the room.

Yendoc
zIStalkerIz
AyumiBot
Carteazy
Coug117
elvortex
epicwinmaster5
GOOD H0RSE
Gpaul2
Jijoo
Killingorgy
MANIE JANIE
Mimeh
Nue
PandaMan88
Phenrex
poncho 04
Quanki
RamenL
The Chad Man
WabamiWonk
wizeowl
zIImp

Send

Bundle
Skins!

npio

YouTube

UNLOCK

Private Chat

Xerath, the Magus
Transcend your enemies with

News

IGN IPL
The IGN Pro League
all over the world do
prize purse. Click he

Xerath Patch N
Find out what's char
Ascendant, to the Le

New Free Char
Greetings Summon

Public Chat 1   Noob   Strategy

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GDC ONLINE 2011

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IS GENERAL CHAT DEAD?

TAKEAWAY
UI

Its OK to be WRONG!
(Your users sometimes are smarter than you are)

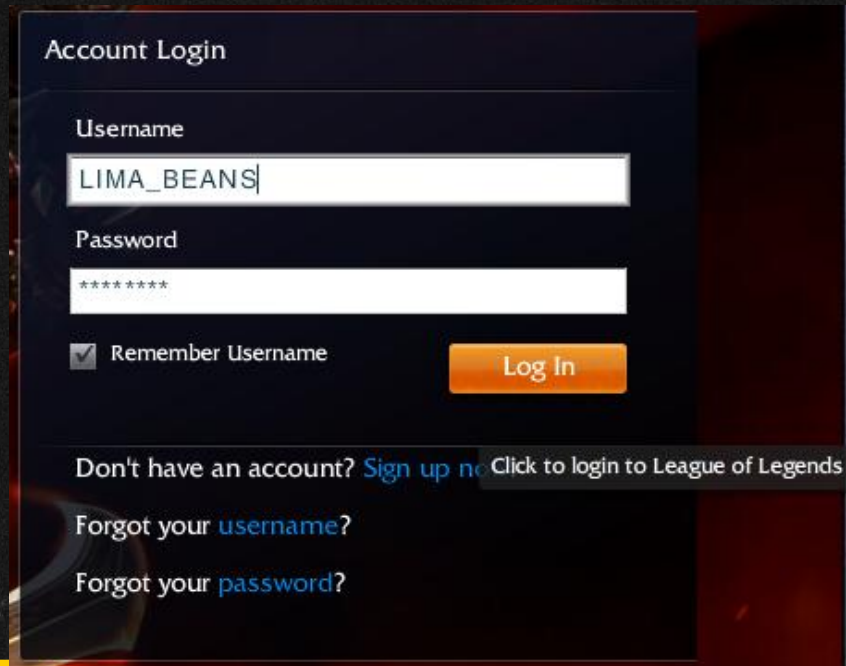Its OK to use Placeholder Art.

Make it very easy to add friends.

Try Usability Testing. We should have!

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PROBLEM 2 —
ENTIRE SERVICE INSTABILITY

But How Is this Possible?

UNDERSTANDING
USER BEHAVIOR

Users reacted to chat outages in a surprising way.

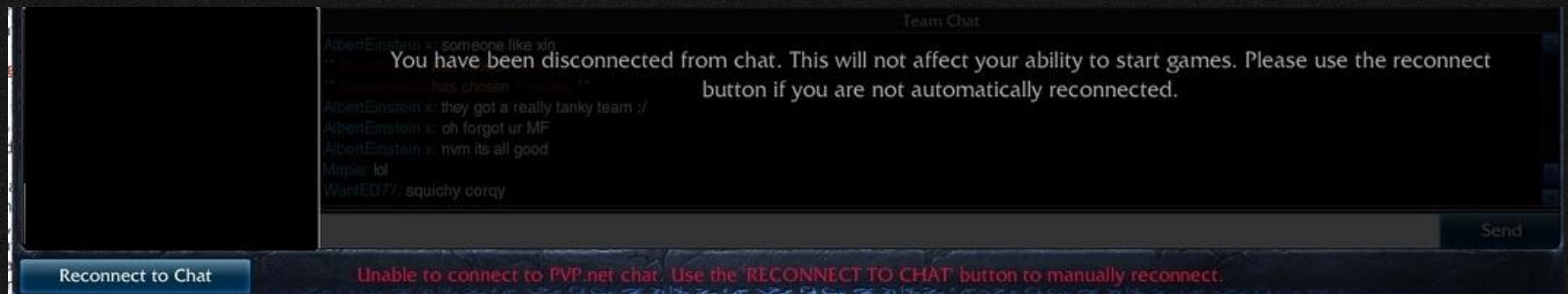Putting big spikes of load on our main service.

UI DESIGN
AND USER BEHAVIOR

Over communicate to users

Give users a call to action.

Added reconnect to chat button!

UI DESIGN
AND USER BEHAVIOR

CPUID: GenuineIntel 5.2.c irql:1f   SYSVER 0xf0000565

Dll Base DateStmp - Name   Dll Base DateStmp - Name
80100000 3202c07e - ntoskrnl.exe   80010000 31ee6c52 - hal.dll
80001000 31ed06b4 - atapi.sys   80006000 31ec6c74 - SCSIPORT.SYS
802c6000 31ed06bf - aic78xx.sys   802cd000 31ed237c - Disk.sys
802d1000 31ec6c7a - CLASS2.SYS   8037c000 31eed0a7 - Ntfs.sys
fc698000 31ec6c7d - Floppy.SYS   fc6a8000 31ec6ca1 - Cdrom.SYS
fc90a000 31ec6df7 - Fs_Rec.SYS   fc9c9000 31ec6c99 - Null.SYS
fc864000 31ed868b - KSecDD.SYS   fc9ca000 31ec6c78 - Beep.SYS
fc6d8000 31ec6c90 - i8042prt.sys   fc86c000 31ec6c97 - mouclass.sys
fc874000 31ec6c94 - kbdclass.sys   fc6f0000 31f50722 - VIDEOPORT.SYS
feffa000 31ec6c62 - mga_mil.sys   fc890000 31ec6c6d - vga.sys
fc708000 31ec6ccb - Msfs.SYS   fc4b0000 31ec6cc7 - Npfs.SYS
fefbc000 31eed262 - NDIS.SYS   a0000000 31f954f2 - Win32k.sys
fefa4000 31f   .SYS
feb8c000 31e   Application Error   [X]   s
feacf000 31f   s
fc550000 316   .sys
fc718000 31e   Bluescreen has performed an illegal operation. Bluescreen must be closed.   SYS
fc870000 31e   SYS
fc5b0000 31e
fea3b000 31f
                               OK
Address   dwo   ?
fec32d84 801   secDD.SYS
801471c8 801   toskrnl.exe
801471dc 801   toskrnl.exe
80147304 803   toskrnl.exe

Restart and set the recovery options in the system control panel
or the /CRASHDEBUG system start option.

YOU FAIL AT FAILING
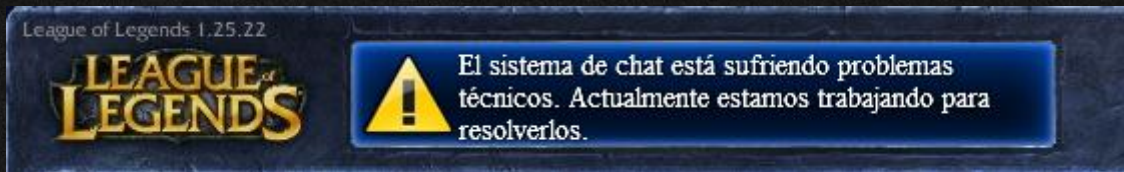
No, that's not a double negative.

DIY.DESPAIR.COM

UI DESIGN
AND USER BEHAVIOR

Ticker System – Gave players a next step for help.

Helped avoid cascading forum failure.

FAULT
TOLERANCE

For **when** your service fails. Not **if**.

TAKEAWAYS

Watch and understand how your users actually use your product.

Better yet – **BE A USER**!

Empathy is a powerful force

Empathy cat
wants to hear your problems
ICANHASCHEEZBURGER.COM

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TAKEAWAYS

We Have training classes for our developers!

Over Communicate to users what is going on.

No programmer error messages

PROBLEM 3 —
CHAT DIDN'T SCALE

Up to 2 Chat Service Crashes Per Day.

WHY ARE WE
NOT SCALING?

XMPP is used at much larger concurrencies.

Why are we any different?

AGAIN: Look at your specific usage pattern!
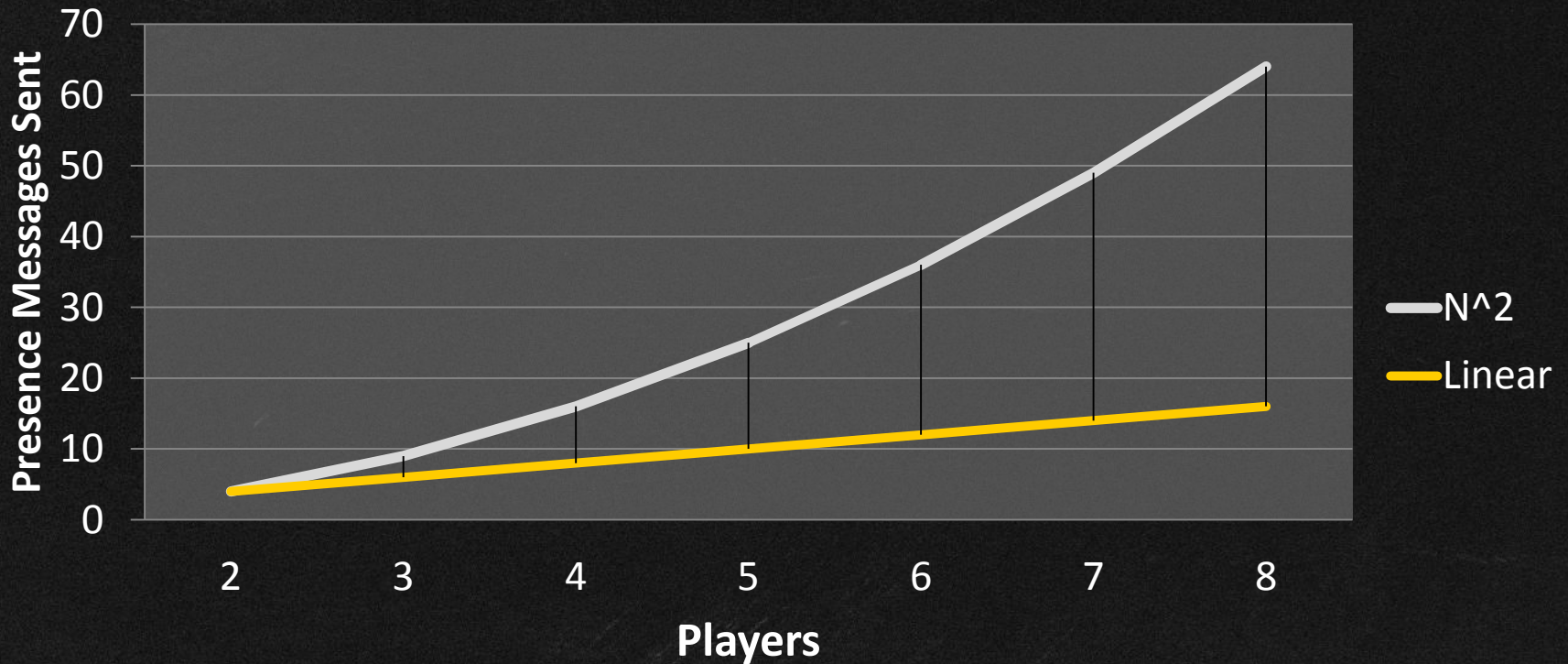
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SCALE CHALLENGES
FOR GAMES

More Frequent Presence changes

More Frequent Chat Room Usage (80k+/hour)

Chat Rooms exacerbate presence issue.

PRESENCE CHALLENGES

Linear VS Quadratic Growth

Chart showing "Presence Messages Sent" (y-axis, 0 to 70) vs "Players" (x-axis, 2 to 8). Two curves: N^2 (quadratic growth, gray) and Linear (yellow).

WHY NOT
JUST FIX IT?

We released patch after patch for months.

But, as scale grew we continued to fall over.

Why couldn't we fix it?

WHY NOT
JUST FIX IT?

Effort != Results

SCALE MISTAKE #1:
DIDN'T UNDERSTAND THE TECHNOLOGY!

Treated XMPP as a black box

NOTHING is fire and forget!

Erlang is BLACK MAGIC WIZARDRY!!

Relied purely external support

SCALE MISTAKE #2:
OUR DATA WAS FLAWED!

We were guessing what the problem was.

But, we didn't really know the true issue.

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SCALE MISTAKE #3:
WE COULDN'T TEST OUR SOLUTIONS!

Live is very different from test environments.

We used our players as Guinea pigs!

I DON'T ALWAYS TEST MY CODE

BUT WHEN I DO I DO IT IN PRODUCTION

memegenerator.net

THE ROAD TO REDEMPTION

Temporarily halted feature development

Began to pay back our Technical Debt

WHAT IS
TECHNICAL DEBT?

Under "Release Early, Release Often", long term issues sometimes get left in the dust.
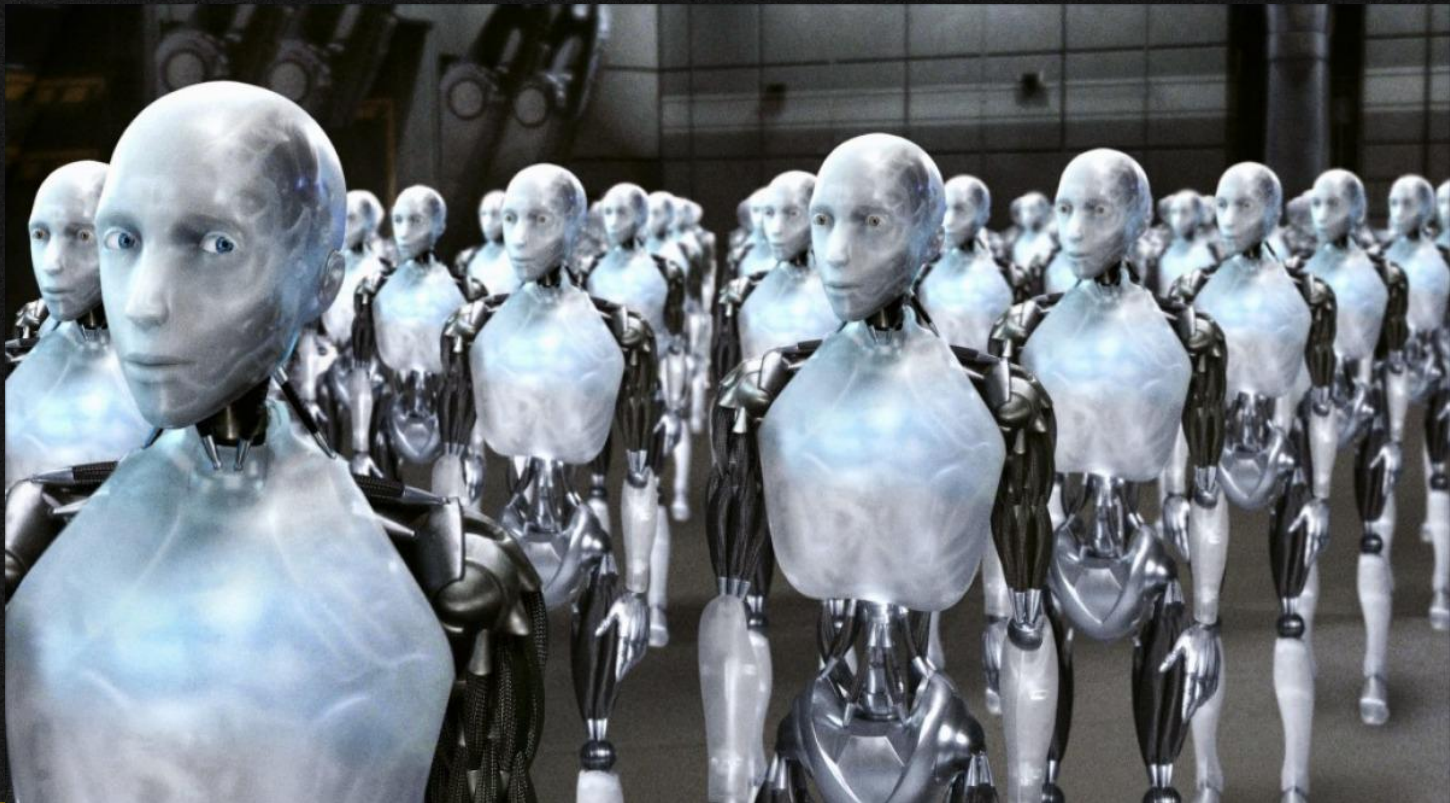
Longterm Code quality and process suffers.

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IS TECH DEBT BAD?

Why Not Just do it Right the first time?

"Just as a business incurs some debt to take advantage of a market opportunity developers may incur technical debt to hit an important deadline" – *Martin Fowler*

SOLUTION
LOAD TEST HARNESS

Spin-up thousands of client bots to simulate load

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SOLUTION
LOAD TEST HARNESS

Smack Api -- XMPP client library by Ignite.
http://www.igniterealtime.org/projects/smack/

Amazon "Elastic Compute Cloud" (Ec2) to host
fake clients. http://aws.amazon.com/ec2/

SOLUTION
LOAD TEST HARNESS

Run about 5-9k fake clients per Ec2 node

Fire up dozens of ec2 nodes at once to simulate load.

Lots of dials/knobs to tune expected behavior.

SOLUTION
LOAD TEST HARNESS

Hey this is pretty cool!

Unfortunately, Useless without proper modeling.

Make sure client guys are on board as well.

Underestimated Chat Room usage drastically

Made results way too optimistic.

SOLUTION
DATA GATHERING

Spent 2 weeks to write our own data gathering modules for ejabberD

Leveraged SNMP (http://sourceforge.net/projects/snapp/)

Used Cacti (http://www.cacti.net/) for visualization.
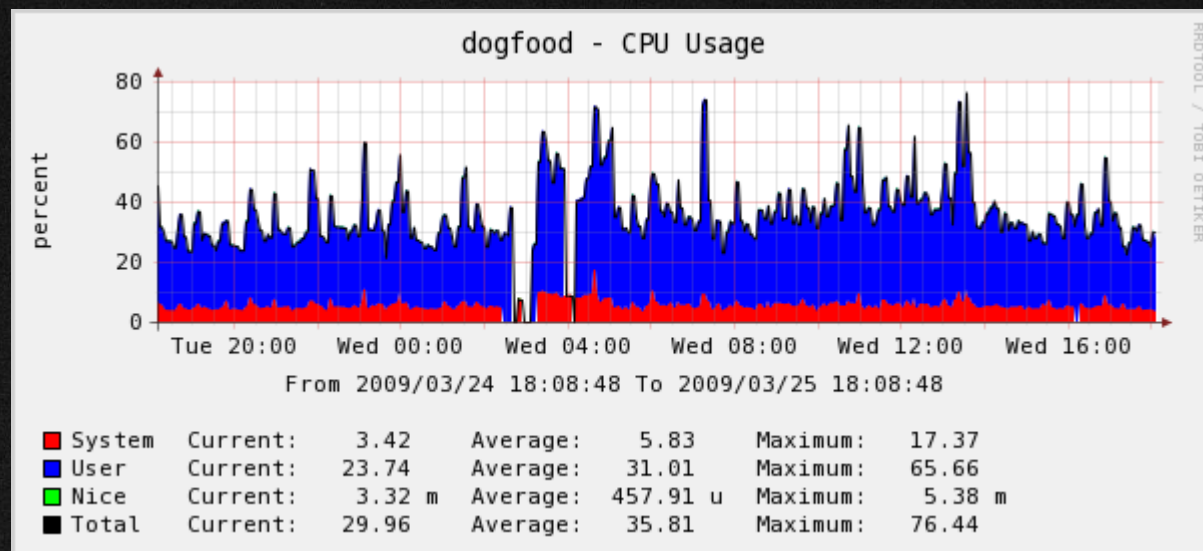
SOLUTION
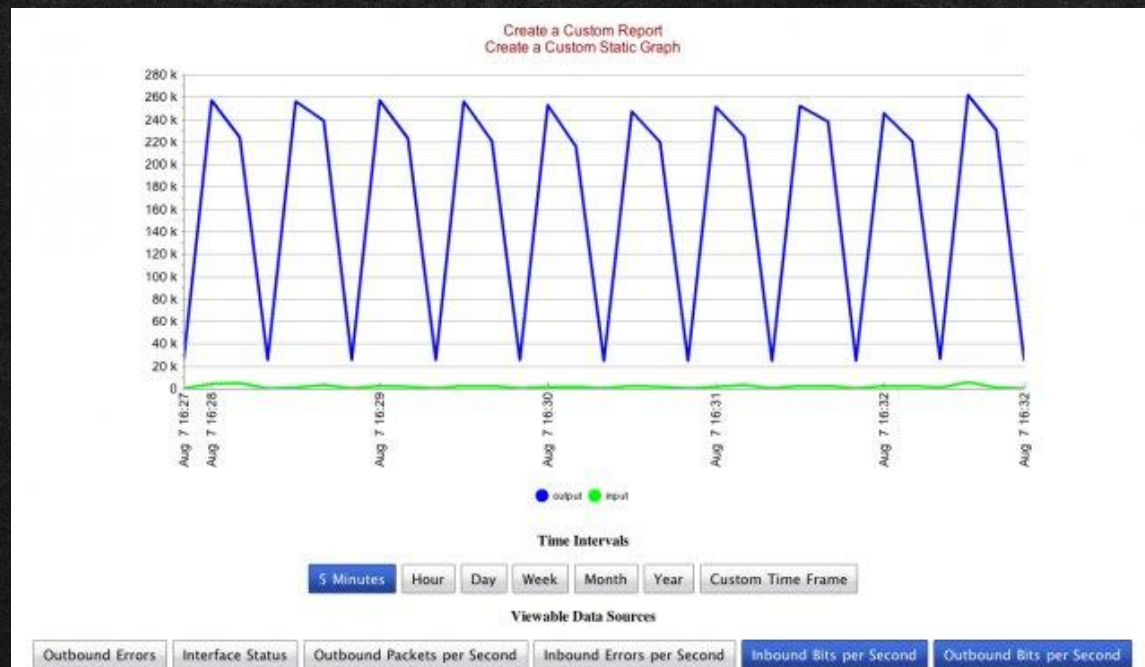# DATA GATHERING

CPU load

Network Load

IO

Chat Room creation

Presence changes

Connections

SOLUTION
UNDERSTAND THE TECHNOLOGY

Began to cultivate internal expertise.

Looked for external partners that had experience with our level of scale.

Problems are completely different at Different Levels of scale!

ERLANG
IS PRETTY COOL AFTER ALL!

Great language for the chat problemspace

Extremely efficient at message throughput

Can do a lot with less, terser code.

Facebook and Erlang: Eugene Letuchy

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COMPARISON - MERGE SORT

Erlang

Single-threaded version:

```erlang
mergeSort(L) when length(L) == 1 -> L;
mergeSort(L) when length(L) > 1 ->
    {L1, L2} = lists:split(length(L) div 2, L),
    lists:merge(mergeSort(L1), mergeSort(L2)).
```

Multi-process version:

```erlang
pMergeSort(L) when length(L) == 1 -> L;
pMergeSort(L) when length(L) > 1 ->
    {L1, L2} = lists:split(length(L) div 2, L),
    spawn(mergesort, pMergeSort2, [L1, self()]),
    spawn(mergesort, pMergeSort2, [L2, self()]),
    mergeResults([]).

pMergeSort2(L, Parent) when length(L) == 1 -> Parent ! L;
pMergeSort2(L, Parent) when length(L) > 1 ->
    {L1, L2} = lists:split(length(L) div 2, L),
    spawn(mergesort, pMergeSort2, [L1, self()]),
    spawn(mergesort, pMergeSort2, [L2, self()]),
    Parent ! mergeResults([]).
```

Java

```java
import java.util.LinkedList;
public class Merge<E extends Comparable<? super E>> {
    public LinkedList<E> mergeSort(LinkedList<E> m){
        if(m.size() <= 1) return m;

        int middle= m.size() / 2;
        LinkedList<E> left= new LinkedList<E>();
        for(int i= 0;i < middle;i++) left.add(m.get(i));
        LinkedList<E> right= new LinkedList<E>();
        for(int i= middle;i < m.size();i++) right.add(m.get(i));

        right= mergeSort(right);
        left= mergeSort(left);
        LinkedList<E> result= merge(left, right);

        return result;
    }

    public LinkedList<E> merge(LinkedList<E> left, LinkedList<E> right){
        LinkedList<E> result= new LinkedList<E>();

        while(!left.isEmpty() && !right.isEmpty()){
            //change the direction of this comparison to change the direct
            if(left.peek().compareTo(right.peek()) <= 0) result.add(left.r
            else result.add(right.remove());
        }

        result.addAll(left);
        result.addAll(right);
        return result;
    }
}
```

SOLUTIONS

Only about 2 weeks to implement most important scaling solutions!

Simple, focused solutions targeted at our specific use case.

SOLUTIONS

Biggest gains: Targeted Chat Room optimizations

- Simplified Chat Rooms

- Replicate Chat Rooms Table to Local Only

Removed Second Game Chat Connection

SCALE
TAKEAWAYS

Identify your non-linear bottleneck

Understand your technology

Understand your use-cases

Gather real data

Be Prepared to pay back Technical Debt

PROBLEM 4:
SECURITY

Chat is Compromised!

With Open Source and Open Standards comes
Great Responsibility.

IM IN UR AKOUNT

SHARDING UR PURPLZ

SECURITY

Name Changes

Employee Spoofing

Room ownership

Word Filtering

Spam

Character Limits

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SECURITY

Game Security != Chat Client Security

Nicknames are client trusted in XMPP!

SECURITY
SOLUTIONS

Mostly configuration changes

Custom Code: EjabberD authenticate with platform and enforce the true summoner name

Don't trust the client!

Even in non-competitive games, Chat needs to be secure   .

PRESENCE
AND CHAT ROOMS

So why are chat rooms and presence so damn important anyways?

And now that we are stable...

How can we use these to actually OFFLOAD major work from the main game service?

PRESENCE

Rinoa
Level 30
twitter.com/Rinoaaa
Won: 554 (Normal)
Ranked 5x5 Solo:
Rating:1508
Won: 10 - Lost: 9
Online

PRESENCE

Naïve Implementation is N^2 again!

Presence information already does this for you!

PRESENCE
IMPLEMENTRATION

XML stanzas

Stats

Level

GameState

PRESENCE

Very little scale impact on main service

Chat rooms already built into all screens: They have Presence information!

Immense social gain

Bragging rights

LEAGUE of LEGENDS

Arranging Team... ✕

Lima Beans | 7554

Your Team

Lima Beans
Level 30
Top Rating: 1271
Ranked: W: 4 - L: 3
Normal: W: 221

Temujinz
Level 30
✕ 👤 ↩
Normal: W: 424

RougeX
Level 30
✕ 👤 ↩
Normal: W: 1344

Cycrum
Level 30
✕ 👤 ↩
Normal: W: 989

bobbyhankhill
Level 30
✕ 👤 ↩
Top Rating: 1667
Ranked: W: 41 - L: 23
Normal: W: 505

Cancel | Start Game

Map Options

Map: The Crystal Scar
Team Size: 5x5
Queue Type: Normal

🌙 Invite

Sleezy McCheezy	PENDING
Temujinz	Accepted
Rayven	PENDING
Footman	PENDING
Fuzzery	PENDING

Invite

All Chat

Draktor: I was just playin with footman O.o
Cycrum joined the room.
Cycrum: yo
Lima Beans: need a screeshot of a full lobby here haha
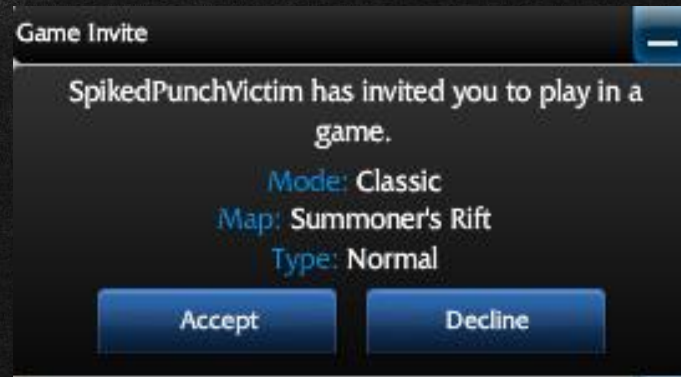Temujinz joined the room.
Lima Beans: oh hai
RougeX joined the room.

Send

OTHER USES OF CHAT

Game Invites

Trades

And More...!

CHAT
SECURITY?

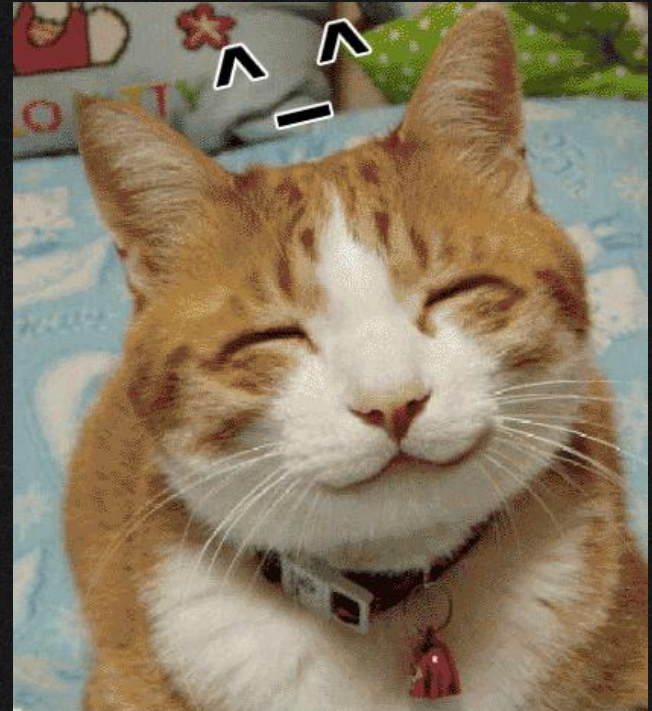Hacking concerns?

Remember: Don't trust the client!

- Final lightweight verification passes with the server.
- Client Sanity Checking
- Lazy Updating From server
- Etc

It's worth the scale gains.

WE DID IT!!
REDEMPTION

It was a long hard road but......

Chat is stable and functional now!

UPTIME

99%

RECAP
PROBLEMS

1) UI

2) Cascade Failures

3) Scaling

4) Security

FINAL
TAKEAWAY

?

THANK YOU!!!

Nathan Beemer

Scott Delap

Chris Yunker

Scott Gelb

QUESTIONS?

Christopher McArthur

@christopurr
cmcarthur@riotgames.com

All of the links and tech from this presentation:
christophermcarthur.com/gdco2011

We're hiring - riotgames.com/careers

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