Writing Massively Multiplayer Online Games With Project Darkstar

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Java

Sun microsystems

Project Darkstar Applications

Business and technology

The hows and whys of writing applications for the Sun™ Game Server (SGS)

What Will Be Covered

- The Business of Project Darkstar (10 min)
- Introduction to Project Darkstar
- The SGS Coding Model IN BRIEF
- Real Game Implementation: DarkMMO
- Where to Go for More Information
- Q&A

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- **The Business of Project Darkstar (10 min)**
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Why Project Darkstar?

- Personal interest
- Sun Microsystems' experience in on-line systems
- New approach to "old" problem
- Interest in growing the on-line game market

New Gameplay Opportunities

- MMOs today are not “massive” — but the potential audience is
- Allows players to engage in content from a variety of locations — “Live Anywhere” is a Sun concept
- Touch the player on mobile, set-top, PC
- Levels the playing field for all developers
- Explosion of niche content possible through Project Darkstar

New Business Opportunities

- Open Source can be free as in “free puppy”
- Services—Sun is best positioned to support
- We make systems and solutions—Project Darkstar brand servers
- On-line Services—the cable TV model for on-line games
- Commercial licensing—innovate and expand, but you own it

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- The Business of Project Darkstar (10 min)
- **Introduction to Project Darkstar**
  - Jeff Kesselman, Chief Instigator
  - Goals and Purpose of Project Darkstar
  - Architecture of Project Darkstar
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Purpose of the SGS

Problem it is intended to solve

- Make practical, massively scalable 5–9s on-line game content in host-able model
  - Enable better games with more, smaller developers
- Current state of the massively multi-player on-line (MMO)game industry
  - $20M - $30M base budget for an MMO
  - Scale only by dividing users, primitive world space- based load balancing (“zones” and “shards”)
  - Limited persistence and no fault-tolerance
  - Each game is a one-off

Purpose of the SGS

Design goals

- Make distributed persistent, fault-tolerant game servers easy and economical to write and administer
  - For the Developer
    - Make server-side game code reliable, scalable, persistent, and fault-tolerant in a transparent manner
    - Present a simple single-threaded event-driven programming model to the developer; the developer should never have his or her code fail due to interactions between code handling different events
  - For the Operator
    - Single point of administration
    - Load balance across entire data center

Architecture of the SGS

Simplified and very brief

- In design much like a 3-tier enterprise system
  - Tier 1: Communications Layer
    - Publish/subscribe channels and direct client/server packets
    - Analogous to the “edge tier”
  - Tier 2: Execution Kernel
    - Executes “tasks” in response to “events”
    - Analogous to a Java™ 2 Platform, Enterprise Edition (J2EE™) platform app server
  - Tier 3: Object Store
    - Lightening fast, highly scalable access to persistent objects
    - Analogous to the DB tier

Architecture of the SGS
Simplified and very brief

- In **execution** very different
  - Tier 1: Communication
    - Reliable/unreliable ordered/unordered byte packet transport
    - Pluggable transports
    - **Optimized for lowest worst case latency**
  - Tier 2: Execution
    - Persistence of objects is ubiquitous and transparent (mostly)
    - Tasks are apparently mono-threaded
    - Objects are very simple, mostly normal Java 2 Platform, Standard Edition (J2SE™ platform)
    - Stateless
    - **Optimized for lowest worst case latency**

Architecture of the SGS

Simplified and very brief

- In **execution** very different
  - Tier 3: Object Store
    - All application state lives here
    - Custom in-memory data-store with secondary storage backup
    - Transactional and fault-tolerant but **not relational**
    - Deadlock detection for tier 2
    - Built to scale massively
    - **Optimized for lowest worst case latencies**

What Will Be Covered

- The Business of Project Darkstar (10 min)
- Introduction to Project Darkstar
- **The Project Darkstar Coding Model**
  - Tasks and Managers
  - ManagedObjects and ManagedReferences
  - AppContext and Managers
  - Communication
- Real Game Implementation: DarkMMO
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Events and Tasks

Events

- Events are occurrences to which application code responds
- There are two kinds of events
  - System events
    - Generated by the Project Darkstar infrastructure
    - initialize() and loggedIn()
  - Manager events
    - Generated by Project Darkstar managers
    - Managers are pluggable additions to the infrastructure
    - All events other then those above come from managers
- Events result in a Task being queued for execution

Events and Tasks

Tasks

- A task is a thread of execution
- Task execution **appears** to be mono-threaded
  - Task is transactional (ACID properties)
    - Appears to all happen at once to rest of system
  - Tasks take read and write locks on game objects
    - Locks freed at end of task
  - Tasks abort and reschedule if a conflict arises
- Tasks scale out horizontally over the back-end
  - Not a detail you need to think about
  - Just remember: fewer object access conflicts == greater scalability

Events and Tasks

Task ordering

- Task execution is mostly unordered and parallel
- **However,** relative task ordering for a single user's input is assured
  - Actions get executed in the order they arrive at the server
  - An event generated by a user will not start processing until all processing of earlier events have successfully completed
- **And** parent-child task ordering is assured
  - A task may use the TaskManager to queue child tasks
  - A child task will not start processing until its parent task has successfully completed

Events and Tasks

Event listener interfaces

- All events have a listener interface associated with them
- ManagedObjects that wish to handle the event must implement the appropriate interface
- When a task for an event starts processing, it looks up and calls the handler for that event

Managers

- Are pluggable components of the infrastructure
- Present an API to the application
- Generate events
- Three standard managers:
  - Task Manager
  - Data Manager
  - Communication Manager

ManagedObjects

Persistent Project Darkstar objects

- An app is made of ManagedObjects
- ManagedObjects
  - Live in the object store
  - Are fetched and locked by Tasks
  - Are written back at successful termination of event
  - Are apparently mono-threaded in execution
  - Are referenced through ManagedReferences
  - Are normal Java objects that
    - Are Serializable
    - Implement the ManagedObject marker interface

ManagedReference

References to ManagedObjects

- **All ManagedObjects must store references to other ManagedObjects in ManagedReferences**
- ManagedReferences
  - Are Java platform reference types (like WeakReference etc.)
    - Have the usual get() method
    - Also have getForUpdate()
  - Mark the persistence boundaries between ManagedObjects

Example of ManagedObject Fields

```
public class Foo implements Serializable, ManagedObject
{

// bytes is part of the persisted state of foo
    byte[] bytes;

// junkString is a transient and is not persisted
    transient String junkString;

// barRef is a reference to a ManagedObject that has its
// own state
    ManagedReference barRef;

    ...
```

So where do you get a ManagedReference from?

Communication

- Two kinds of Project Darkstar communication
  - Client /Server
    - Directly between one client and the server
      - Used to send commands to server and get responses
    - Supported by the kernel
      - Accessed through ClientSession.send(...) on Server
      - Accessed through ServerSession.send(...) on Client
  - Communication Channels
    - From server to many clients
    - Supported by ChannelManager
      - Controlled through ChannelManager on server
      - Accessed through ClientChannel/ClientChannelListener on client
    - More efficient then single cast

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Real Game Implementation

- DarkMMO
  - A basic MMORPG skeleton
    - Movement
      - Server side cheat detection
      - Zone traversal
    - Chat
      - Scoped to area
    - Inventory management
      - Get/Drop
    - Server side logic
      - Open/Close/Use

What We Will Cover

- Basic intro to design
- A look at the hardest problems
- Demo of result

What We Will Cover

- Basic intro to design
- Demo of result

First Step: Consider Technical Challenges

- Consider your latency issues early
  - Set design limits
    - DarkMUD designed for approximately 1000msec worst case
  - Consider results of latency spikes
    - Real time game
    - Limited guess/correct possible
  - Easiest just to allow remote lag
    - Respond locally immediately
      - Check results with server for correctness
    - Allow others to lag on screen
      - Loose combat model covers most ills

First Step: Consider Technical Challenges

- Consider your scaling issues early
  - Set design limits
    - DarkMUD should scale to tens of thousands of simultaneous players
  - N-squared is the enemy
    - Divide and conquer
      - World is zoned
      - Zones are tile-based
      - Limit awareness to size of one tile
    - Global chat needed
      - Limit to Buddy-lists

Second Step: Define Your ManagedObjects

- Entities
  - Players
  - Characters
  - MOBs
  - Placeables
  - Zones
  - Tiles
  - Walk Meshes

Second Step: Define Your ManagedObjects

- Entities
  - Players
    - Represent a user account
    - Has permissions
    - Owns multiple characters
  - Characters
  - MOBs
  - Placeables
  - Zones
  - Tiles
  - Walk Meshes

Second Step: Define Your ManagedObjects

- Entities
  - Players
  - Characters
    - Player's proxies in the game world
    - Have game statistics
    - Move around
    - Fight
    - Interact
  - MOBs
  - Placeables
  - Zones
  - Tiles
  - Walk Meshes

Second Step: Define Your ManagedObjects

- Entities
  - Players
  - Characters
  - MOBs (Mobile Objects)
    - Non-player characters
    - Move around
    - Have AI
    - Have game statistics
    - Fight
  - Placeables
  - Zones
  - Tiles
  - Walk Meshes

Second Step: Define Your ManagedObjects

- Entities
  - Players
  - Characters
  - MOBs
  - Placeables
    - Can block movement
    - Do not move around
      - May be moved (?)
    - Interact with players and MOBs
  - Zones
  - Tiles
  - Walk Meshes

Second Step: Define Your ManagedObjects

- Entities
  - Players
  - Characters
  - MOBs
  - Placeables
  - Zones
    - Play spaces
    - Made up of tiles
    - Can support transfer from/to
    - Support Players, MOBs and Placeable
  - Tiles
  - Walk Meshes

Second Step: Define Your ManagedObjects

- Entities
  - Players
  - Characters
  - MOBs
  - Placeables
  - Zones
  - Tiles
    - Discrete chunks of geometry
    - Have associated walk mesh
  - Walk Meshes

Second Step: Define Your ManagedObjects

- Entities
  - Players
  - Characters
  - MOBs
  - Placeables
  - Zones
  - Tiles
  - Walk Meshes
    - Simplified tile geometry
    - Labeled with walkable/unwalkable
    - Used to calculate movement blocking
    - Could support terrains
      - E.g., slow walk in “mud”

Second Step: Define Your ManagedObjects

- Mapping of Entities to Events/Interfaces
  - Players
    - Handle user packets: ManagedObject, ClientSessionListener
  - Characters
    - Just game world constructs: ManagedObject
  - MOBs
    - Need to run AI: ManagedObject, Task
  - Zones and Placeables
    - May have timed effects: ManagedObject, Task
  - Tiles, Walk Meshes
    - Just game world constructs: ManagedObject
  - MCP
    - Handles logon/logoff: ManagedObject, AppListener

What We Will Cover

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Third Step: Solve N-squared for motion

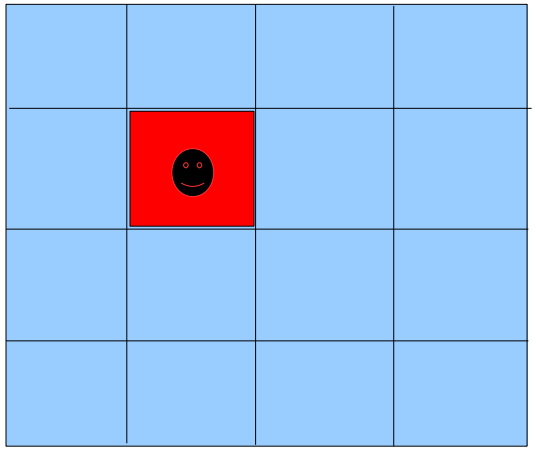
- Do the hardest part first
  - "Walking" is generally your worst case
    - If you can navigate comfortably, the rest is usually easy
    - Movement creates a lot of packets
- Recall:
  - We can allow remote players to lag
  - We can start local movement immediately
  - We can allow remote players to "lag" on local screen
  - Need to cut down number of other players with which we are communicating.

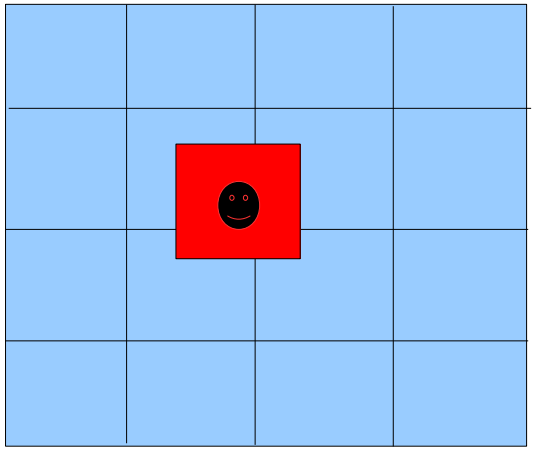
Naïve Solution

- Dynamic space partitioning
  - Quadtree
  - Large structure that must be searched on every position change
  - Must be frequently modified
  - All this spells *contention*
    - Can kill multi-threaded performance

Better Solution

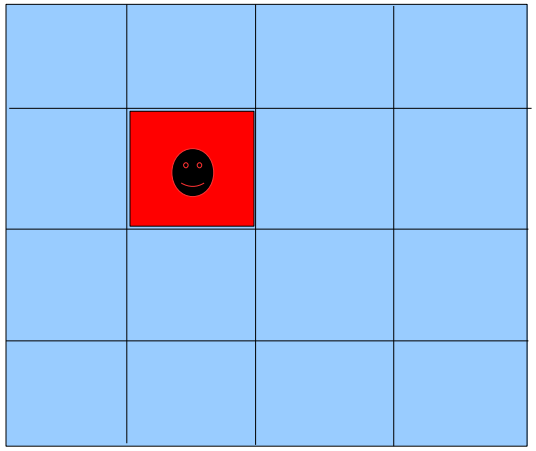
- Grid the Zone
  - Cell size is equal to maximal view distance
    - What cant be seen does not matter
  - Can see at most 4 cells at a time

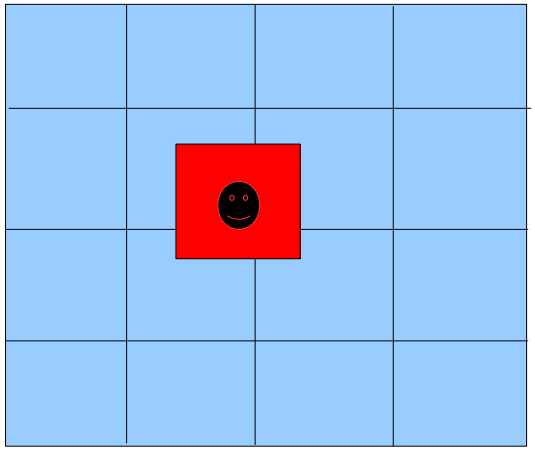




Divide and conquer

- Attach a channel to each cell
  - Player talks to current cell's channel
  - Player listens to the 4 covered by their view
    - Local update to cell contents
    - Low contention





Other Issues

- Positional differences in combat
  - Exact position does not matter
  - Range does
  - Distance between players could be different on different screens
  - Two Cases: Hand to Hand and Ranged

Hand to Hand Combat

- Have a fixed “close range”
- If server decides attacker is within close range
  - Serve locks defender in place
  - Server moves attacker to within melee range
- Issues
  - Traps?
    - Auto detect and walk around or abort attack?

Ranged Combat

- Viewers can't tell exact range
- As long as server thinks target is in range, allow attack
- Server checks blocking
  - If blocked, server sets arrow flight animation
  - If hit, client sets arrow flight animation
- Issues
  - Arrow might occasionally penetrate wall or other block in client's view

DarkMUD

All artwork is from the commercial game Neverwinter Nights

Summary

- Project Darkstar vastly simplifies writing scalable, fault tolerant on-line games
  - BHO written in approximately 1 man week for client and server
- Opportunity for small and big developers
  - Get in without $30M
    - SGS SDK is Open Source
    - Playground program provides free beta-hosting
    - Hosting providers can revenue share
  - Create games you could never afford before
  - Create games across platforms!

For More Information

Lab 7210—Hands-on with Project Darkstar: The JavaOneSM Conference MUD

- For client coding resources in Java code:
  - Slick
    - 2D API used for BHO! and Project Darkstar coursework
      - http://slick.cokeandcode.com
  - JMonkey Engine
    - 3D game engine used for DarkMUD (also being used commercially and in Wonderland)
      - http://www.jmonkeyengine.com
  - Java platform game developer community
    - www.javagaming.org

For More Information

Business Contacts

Jennifer Kotzen – Project Manager
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Technical Contacts

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Q&A

Jeff Kesselman | Chris Melissinos

THANK YOU

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