Writing Massively Multiplayer Online Games
With Project Darkstar

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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
What Will Be Covered

- **The Business of Project Darkstar (10 min)**
  - Chris Melissinos, Sun Chief Gaming Officer
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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
What Will Be Covered

- 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 than 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 theManagedObject 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

```java
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?
```
Communications

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 than 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

• 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

- Basic intro to design
- A look at the hardest problem
- Demo of result
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 can't 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
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Q&A

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THANK YOU

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