

# DALi: Distributed Artificial Life

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# DALi, Inc.

Distributed Artificial Life



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Imagine a virtual world teeming with artificial life. This virtual world is an ocean, and the ocean is populated with a diverse and abundant ecology. Sea horses float among coral reefs, schools of fish dart and weave to evade hungry predators, a mother humpback whale and her calf migrate to cooler waters to feed... Myriad beautiful autonomous creatures are caught in the web of life that plays out before your eyes. As a user you are able to build and influence the ecology of the world, sculpt the surroundings, breed artificial life, or create new life forms from scratch.

Sound like the sort of thing you would like to have running on your computer?

**How about on your computer as well as everywhere else in the world?**

## News:

July 30, 2001

DALi, Inc. has released its first public beta of DALiWorld! **Download DALiWorld**, create an account to join the user community, and begin exchanging fish with people all over the world.

Want to hear about our upcoming product releases? Enter your email address and click the "Join" button below. You will be added to our mailing list.

Email:

[Join](#)

Why search for life when you can create it?

# DALi, Inc.'s History

- ✧ 1997 - student project in advanced distributed systems course at Caltech
- ✧ 1999 - raised money and founded DALi, Inc.
  - ✧ five founders, \$500,000 startup funds
  - ✧ maximum size ~10 employees
- ✧ 2000 - DALiWorld shipped
  - ✧ demonstration application with 1M users
  - ✧ shown at GDC 2000 to several companies and high-profile personalities

# Challenges

modern massive multiplayer experiences  
*do not scale*

- ✱ technology - bytes, latency, dollars of client-server architectures make no sense
- ✱ game development - man-month per entity
- ✱ experiences - zoning worlds, scalability of shared experiences is limited

# Methodology

- ✧ The DALi Solution was to
  - ✧ *identify and implement best results* from the *research community* to
  - ✧ develop *licensable technology* with a
  - ✧ *technology demonstration* that
  - ✧ *solves the scaling problems* inherent in massive multiplayer experiences.

# DALiWorld

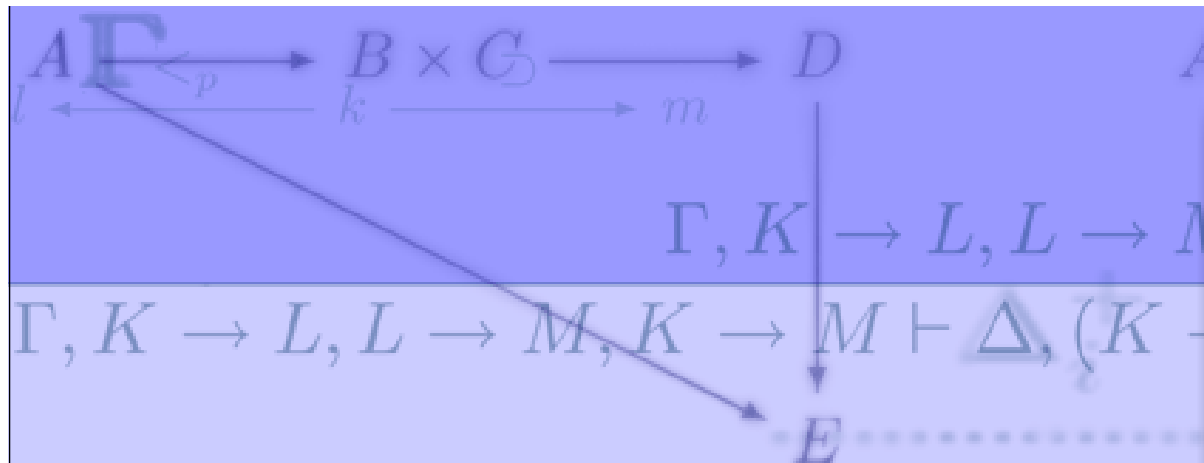
Welcome to



As Featured On

USA Today - BBC - Tech TV - Wired - Business Week

[Enter DALiWorld]



## Daliworld in the News

### US Articles

- [JavaGaming.org](#)  
Game of the Month (08/27/2001)
- [Amarillo Globe-Times](#)  
Creating Life in Cyberspace (08/25/01)
- [Network World](#)  
Gone Fishing (08/20/2001)
- [Techreview.com](#)  
Carpster (08/17/2001)
- [Futureframe news](#)  
The Internet: a global fishbowl (08/16/2001)
- [Silicon.com](#)  
Playing cod: PC owners in virtual fish experiment (08/15/01)
- [FISHINGmagic](#)  
Fish In Cybersea (08/15/2001)
- [Beyond2000.com](#)  
Fish Out of Water (08/15/2001)
- [InformationWeek](#)  
Distributed Computing Creates Virtual Ocean (08/14/2001)
- [lockergnome.com](#)  
Watery Virtual World (08/11/2001)
- [geeknik.net](#)  
New distributed computing project (08/12/2001)
- [USA Today](#)  
From info highway to digital ocean (09/06/2001)
- [Tech TV](#)  
DALIWorld Virtual Fish Tank (08/03/2001)
- [Wired News](#)  
This New App Sounds Fishy (08/01/2001)
- [Business Week](#)  
A Net of Their Own (08/01/2001)
- [Yahoo Finance](#)  
DALI Announces Availability of Largest, Distributed Artificial-Life Platform (07/30/01)
- [PC Magazine](#)  
Going to DALIWorld

### Asian Articles

- [Lycos {translation}](#)  
(08/03/2001)

### Australian Articles

- [Gonefishin.com](#)  
Cybersea (09/20/2001)

### European Articles

- [InetMag](#)  
Virtuální oceán (08/17/2001)
- [T3](#)  
Get creative underwater (08/16/2001)
- [E Magazine](#)  
Skab et virtuelt ocean (08/15/2001)
- [BBC News](#)  
Putting the fish in the net (08/14/2001)
- [Giga.de {translation}](#)  
Schwimmen im Netzwerk (08/02/2001)
- [NOW](#)  
Cybersea (09/20/2001)

### South American Articles

- [Clarín.com {translation}](#)  
Un acuario virtual con peces que pasan de una PC a otra (08/01/2001)

### US Articles

- **JavaGaming.org**  
Game of the Month (08/27/2001)
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CULTURE : LIFESTYLE 

## This New App Sounds Fishy

Michael Stroud  08.01.01

Tired of having the same old fish swim across your screensaver? How about fish that have minds of their own and swim off your screen onto someone else's in, say, Japan?

That's the idea behind [DALiWorld](#), peer-to-peer software that debuted this week. It allows you to create a virtual aquarium on your computer housing your own artificially intelligent fish, and any others that wander by.

The software — the brainchild of three computer scientists and a young dot-com millionaire — is one of the first examples of how a technology best known for song-swapping on the Internet is emerging as a foundation for a new generation of online games.

"Traditional peer-to-peer software like Napster or Gnutella is just about moving files," said DALi CEO Todd Pappaioannou, a PhD from England's Loughborough University and an authority on "mobile agents" software that travels from computer to computer.

"What we're talking about is shared, networked entertainment — people interacting in the same virtual world from wherever they are."

All of the virtual fish and aquariums are built using Sun Microsystems' Java language. And it just so happens that one of Sun's chief goals is to get game developers to write their games in Java — enabling people to access their favorite games over PCs, Macs, interactive televisions, cellular phones and any other computing device. DALi hopes to do exactly that with its fish world over the next year.

DALiWorld is "the poster child," Pappaioannou says, for the tiny company's technology for allowing gamers to trade software agents over massive distances and injecting artificial intelligence into games.

Pappaioannou hopes DALiWorld will evolve into a complex universe where players can create their own creatures, communicate with players from around the world, forage for food and even fiddle with the biochemistry of the virtual environment.

## explore {Ecology}

The ecology of DALiWorld is modeled upon the Indonesian Ocean. We have drawn inspiration from the myriad of different and beautiful creatures that exist in the real world. We have included numerous genus of fish in DALiWorld, including **Angelfish**, **Batfish**, **Butterflyfish**, **Damsel Fish**, **Grouper**, **Leatherjackets** (Triggerfish and Filefish), **Parrotfish**, **Surgeonfish**, and **Wrasse**. Each family has a variety of beautiful species in it. Click on any of the fish families or species to get to know the diverse ecology of DALiWorld.

You may also be interested in finding out about the **special fish** that exist within DALiWorld



Grouper

- Coral Grouper
- Coronation Grouper
- Tiger Grouper
- Yellowfin Grouper
- Marbeled Grouper



Angelfish

- Queen Angelfish
- Regal Angelfish
- Blue-ringed Angelfish
- Rock Beauty
- Six-banded Angelfish



Batfish

- Teira Batfish
- Round-faced Batfish
- Moorish Idol



Butterflyfish

- Raccoon Butterflyfish
- Vagabond Butterflyfish
- Ornate Butterflyfish



Leatherjackets

- Sargassum Triggerfish
- Clown Triggerfish
- Longnose Filefish



Wrasse & Parrotfish

- Clown Wrasse
- Stoplight Parrotfish

## DALiWorld Special Fish

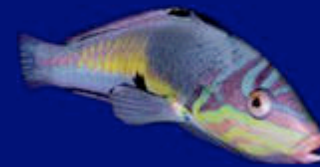
Some of the fish in our ecology have been designated as **Special Fish**. When you start up DALiWorld for the first time, you are assigned one (and only one!) of these as your special fish. When you create new fish in your aquarium some of your special fish may be created (the actual number and frequency is random). This is the only type of special fish you will be able to generate in your aquarium. If you turn on networking however, you might get to see one of the other special fish species too, as they will have the chance to migrate from one of your neighbor's aquariums.



**Sargassum Triggerfish**  
(25 cm)  
*Xanthichthys ringens*



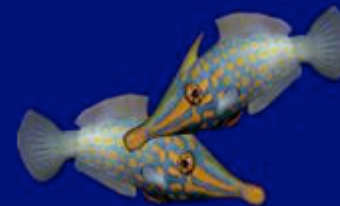
**Clown Triggerfish**  
(12 cm)  
*Balistoides conspicillum*



**Clown Wrasse**  
(14 cm)  
*Halichoeres maculipinna*



**Stoplight Parrotfish**  
(55 cm)  
*Sparisoma viride*



**Longnose Filefish**  
(8 cm)  
*Oxymonacanthus longirostris*

## The DALiWorld Infrastructure

The DALi Infrastructure is a platform that architects large, massively distributed virtual worlds inhabited by artificial life forms. The worlds we build support an exceptionally compelling, interactive and aesthetically appealing user experience where you are able to create new life, build ecologies, and participate in the communities that spring up around this unique distributed virtual world.

The infrastructure is a 100% pure Java, fully componentized, pluggable architecture that ensures platform neutrality and portability. Click on any of the components in the list below to get a more detailed view what sits under our hood.

- **Artificial Life**
- **Learning Systems**
- **Mobile Agents**
- **Graphics Engine**
- **Physics Engine**

- **Physics engine**
- **Graphics engine**

# Technologies

- \* distributed systems - massively scalable peer-to-peer simulation
- \* mobile agents - game entities migrate between hosts
- \* modeling - model properties specified declaratively with archetypes
- \* graphics - multires rendering + LOD + generated textures + no “canned” animation
- \* simulation - realtime physics + multires simulation
- \* learning systems - agents have neural net “brains” and decision tree “emotions”
- \* artificial life - all of the above encode in digital genomes and species are bred, not coded

# Distributed Systems

- ✧ push the boundaries of what is possible with peer-to-peer simulation
- ✧ nodes are responsible for a portion of the world corresponding to their computational and network capabilities
- ✧ migration of entities between nodes is accomplished via mobile agent technology
- ✧ partitioning overlaps and simulation is deterministic (for handover, failure, and to detect cheating)

# Mobile Agents

- ✧ entities in the system are encoded using digital DNA and local current state
- ✧ migration includes DNA and state
- ✧ thus, introduction of new species is via migration, not via patches or updates
- ✧ platform neutral encoding so migration to PCs, consoles, and handhelds is identical



# Modeling

- ✧ entities archetypes are modeled in 3D using only bones, muscles, and skin
  - ✧ range of motion of joints and typical muscle strength encoded here
- ✧ their description is also encoded in DNA using a declarative DSL
  - ✧ description includes symmetries, maximal size and mass, procedural skin textures, sensory capabilities, biochemistry summary
- ✧ environment also modeled in this fashion



# Graphics

- ✧ three experimental rendering engines
  - ✧ textual output summarizing state of sim
  - ✧ 2D perspectives for low-end devices
  - ✧ basic 3D rendering using Java3D
- ✧ multi-resolution rendering with LOD
  - ✧ drop poly count based upon distance to view
  - ✧ corresponding drop in accuracy of meshes
  - ✧ texture rendering at multiple LODs

# Entity Simulation

✧ simulation of entities in full detail includes:

- ✧ biochemistry summary (energy, hunger, hormones, etc.)
- ✧ emotional state (happy, fearful, etc.)
- ✧ current goals (school, pursue food source, interest in mating, avoid predator, etc.)
- ✧ sensory input (sight, smell, and “other”)
- ✧ position, orientation, flexion
- ✧ low-level decision-making based upon goals

# World Simulation

- ⊛ world simulation is a discrete event multi-resolution simulation
- ⊛ visibility of entities and distance from a viewer are the two inputs for multi-res algorithms
- ⊛ simulation in full detail is recorded over a “long” period of time then used to derive statistical behavior when unobserved or when observed from a distance
  - ⊛ i.e., why actuate muscles and do the physics if an entity is only a centimeter tall on the viewport?
  - ⊛ why simulate any behavior when unobserved?

# “Realtime Everything”

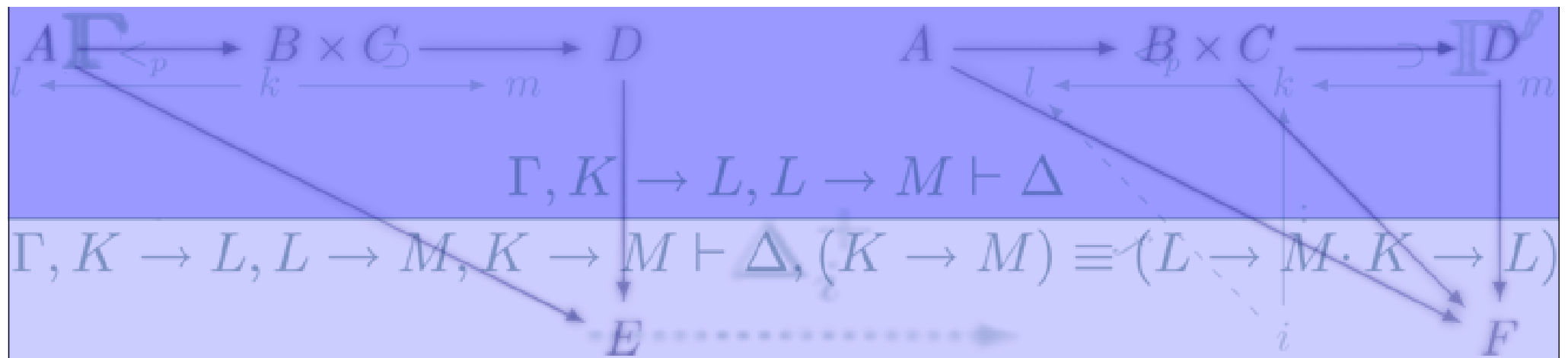
- \* no entity behaviors are programmed
  - \* consequently, output behavior after evolution is unpredictable
- \* all actions are decided and acted upon by entities, not by developers
  - \* entity neural nets drive musculature
- \* custom physics engine computes affect of action, thus motion is computed from physics, not faked from encoded values

# Learning Systems

- ✧ technologies used to effect emotions, goals, and actuation include:
  - ✧ *case-based analysis* for describing states and emotions and their dependencies
  - ✧ *decision trees* to synthesis input and derive micro-scale behavior from macro-scale input
  - ✧ *neural nets* to drive motor response

# Artificial Life

- ✧ declarative description of *species* encoded in digital DNA via bytecode and custom DSL representing base pairs and genes
- ✧ description of an *individual* is encoded in local state (property-value pairs)
- ✧ to evolve a new species...
  - ✧ 1M random entities are generated conforming to DNA
  - ✧ evaluation and breeding based upon simulation and objective function of various goals
  - ✧ 50K generations typical necessary to generate a new species (several hours circa 2K's 350MHz P2)



# Demonstration