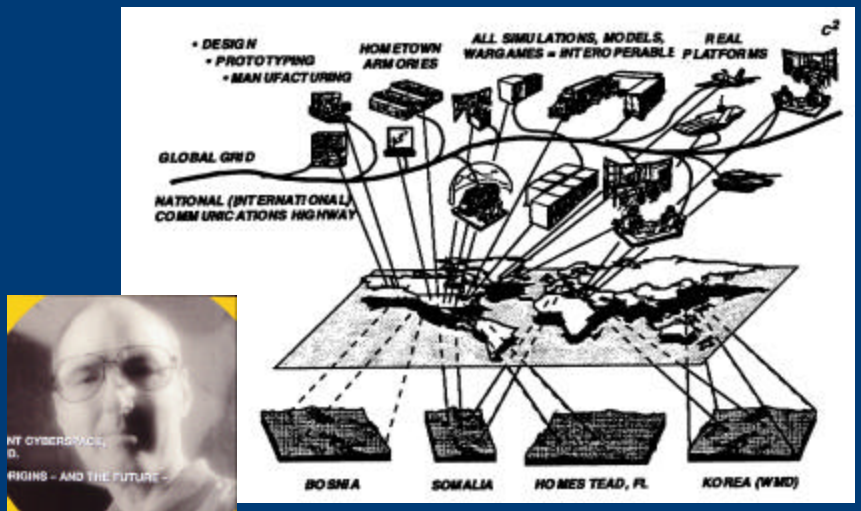
Evolution of Networked Virtual Environments

Class 8

Dr. Roger Smith

http://www.simulationfirst.com/ein5255/

Jack Thorpe's Vision



From Battlezone to SIMNET

Battlezone
1980

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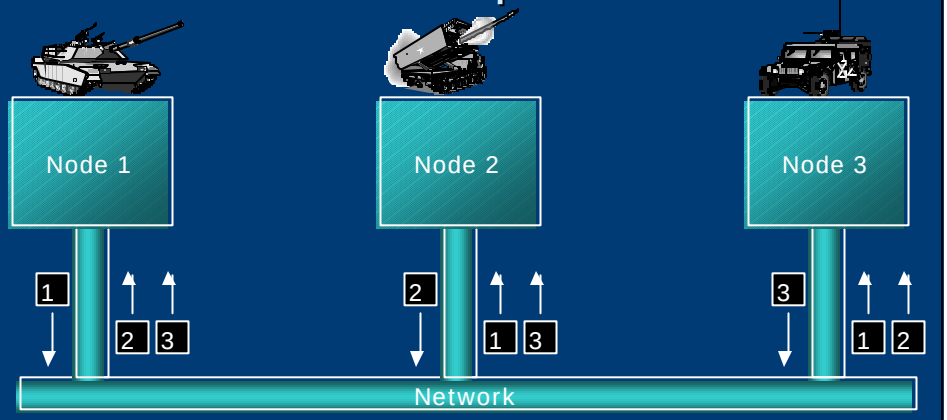
SIMNET
1983-90

SIMNET Design Principles

- Object/Event Architecture
  - Vehicles and Engagements
- Common Environment
  - Terrain and Culture
- Autonomous Simulation Nodes
  - Broadcast Events
- Transmission of Ground Truth
  - Local Perception and Effects
- Transmission of State Change
  - Not Static Data
- Dead Reckoning Algorithms
  - Extrapolate Last Reported State

Object/Event Architecture

SIMNET/DIS Independent Nodes

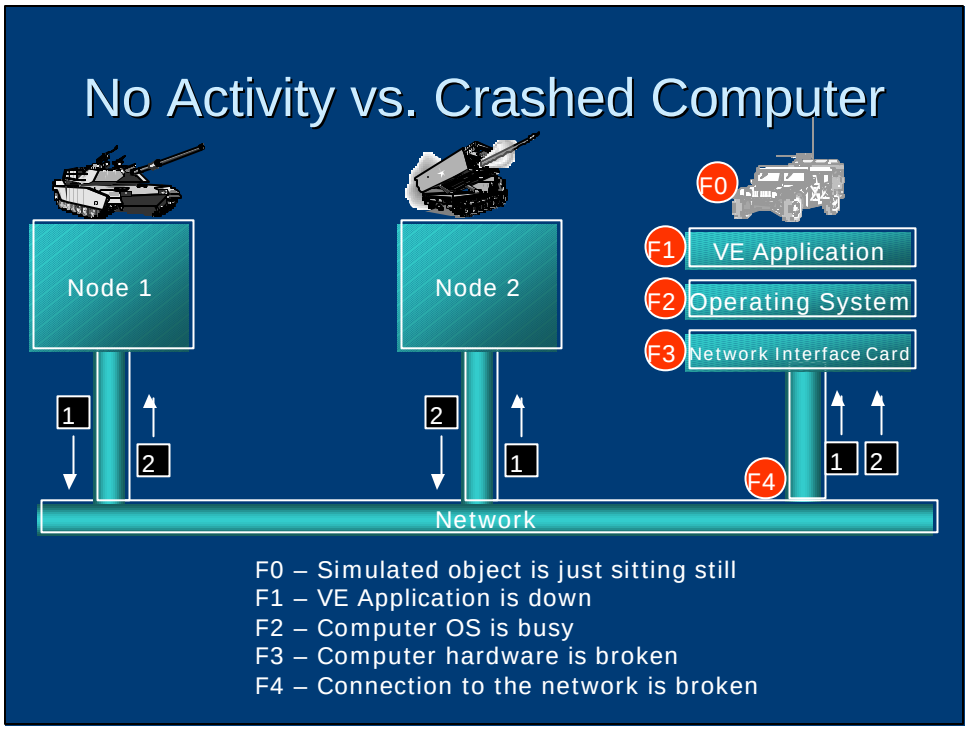


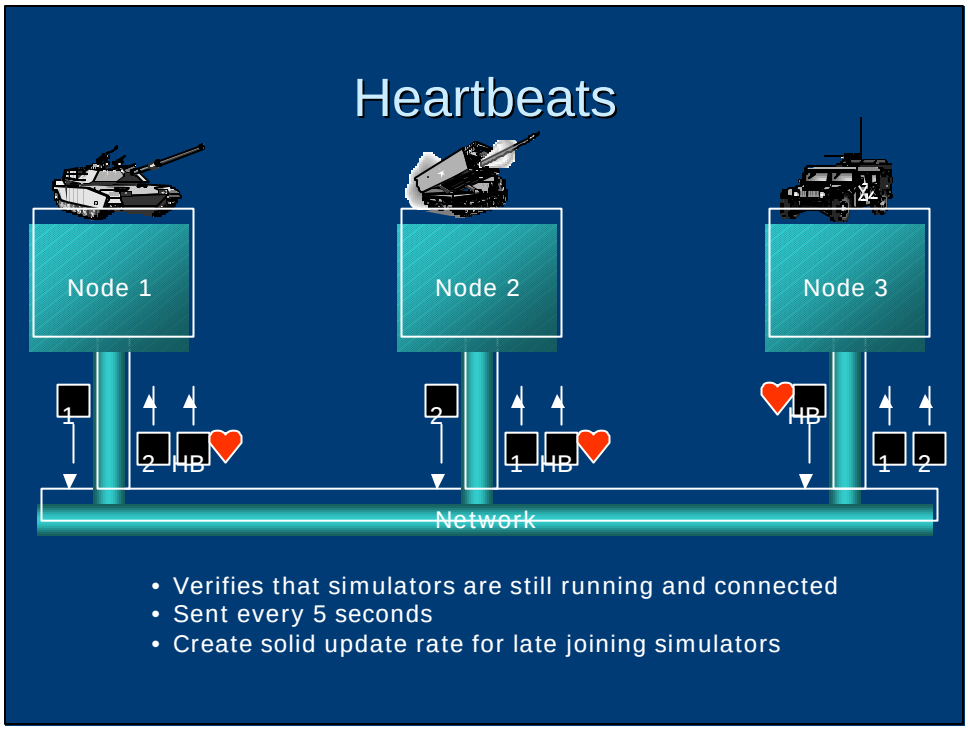
- Reduces System-wide Failure
- Enables Broadcasting to Reduce Message Duplication (255.255.255.255)
- Allows Late Joining or Early Departure
- Eliminates Need for a Simulation Server (Bottleneck)

Update Message = Network Packet

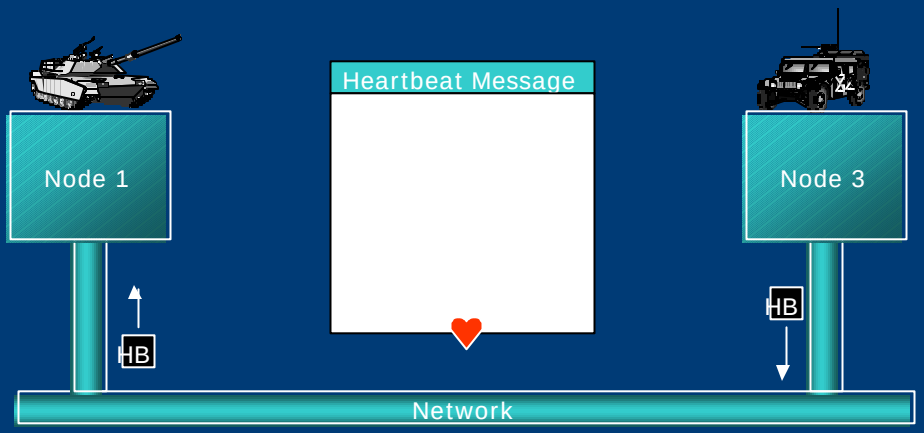
Field Name	Contents	Field Size (bytes)
Vehicle ID	Site Host Vehicle	6
Vehicle Class	Tank Simple Static Irrelevant	1
Force ID		1
Guises	Distinguished Other	8
World Coordinates	Location: X,Y,Z	24
Rotation Matrix		36
Appearance		4
Markings	Text Field	12
Timestamp		4
Capabilities		32
Engine Speed		2
Stationary bit and padding		2
Vehicle Appear Variant	Velocity Vector Turret Azimuth Gun Elevation	24

Total = 156 bytes





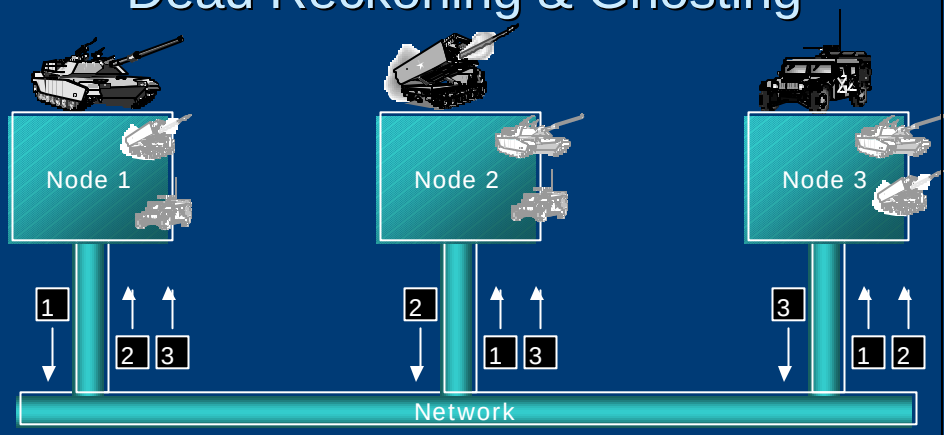
What needs to be in a heartbeat?



Update/Message Rate

- Frame Rate
  - Guarantees accurate representation
  - Strong impact on number of nodes on network
  - Difficult to connect different simulations
- Significant Events
  - Messages on changes
  - Heartbeats to keep alive
- Dead Reckoning
  - Greatly reduce network traffic
  - Increases max nodes on network
  - Brings together sims with different rates
  - Requires ghosting remote objects

Dead Reckoning & Ghosting



- Keep local copy of all objects
- Update locations based on last known position, orientation, velocity, acceleration, radial velocity, etc.
- Common library of DR algorithms shared by all sims

Orders of Dead Reckoning

Zeroth-order DR	DrLocation = LastKnownLocation
First-order DR	DrLocation = LastKnownLocation + LastKnownVelocity * TimeElapsed
Second-order DR	DrLocation = LastKnownLocation + LastKnownVelocity * TimeElapsed + (1/2)*LastKnownAcceleration*TimeElapsed^2

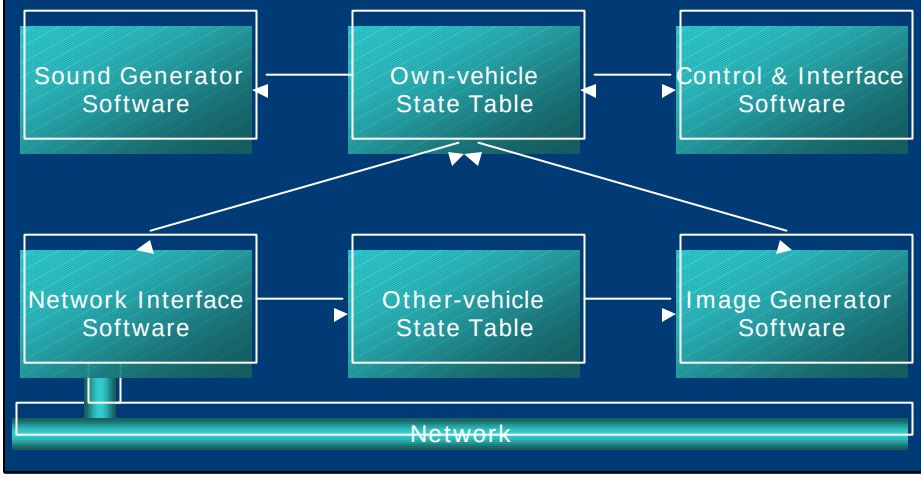
"Skate to where the puck will be – not where it has been."
- Wayne Gretsky

DR Savings - Examples

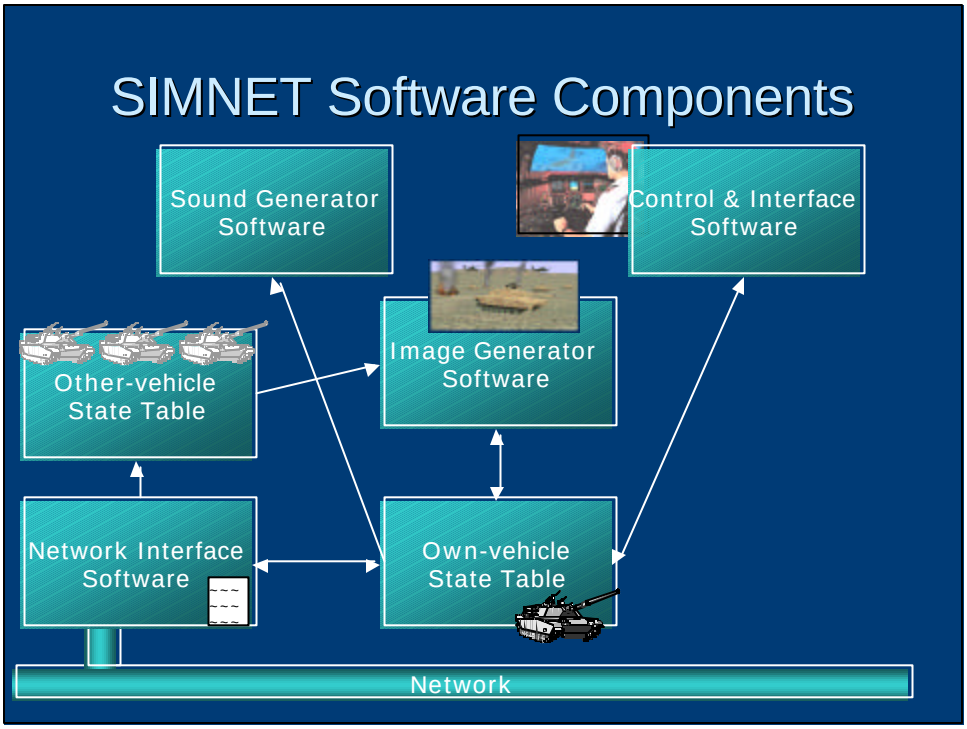
	Without DR	With DR
	10-15 updates/second	1 update/second
	30-60 updates/second	3 updates/second

Allows at least 10X increase in number of objects in virtual world.

SIMNET Software Components



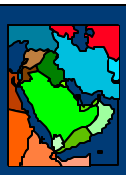
SIMNET Software Components



1987 Canadian Armor Trophy

- US Armor Crews Prepare with SIMNET
- Simulation Allows Many More Practice Sessions
- US Team Wins Canadian Armor Trophy for first time in a Decade

Battle of 73 Easting



- Battle of 73 Easting, 26 February 1991
  - 2nd Armored Cavalry Regt destroyed dug-in Iraqi Armor Division
- Data collection to pinpoint vehicle locations, movements, and engagements
- Soldier review to refine events
- Replay of a real engagement in 3D environment
- Stimulus for huge visions of future simulations

Distributed Interactive Simulation

- Object/Event Architecture
  - Vehicles and Engagements
- Common Environment
  - Terrain and Culture
- Autonomous Simulation Nodes
  - Broadcast Events
- Transmission of Ground Truth
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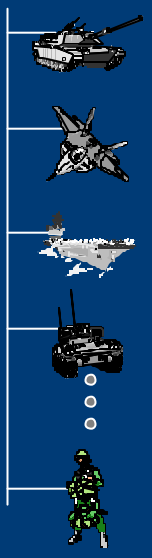


Entity State PDU

Field Size (Bits)	Entity State PDU Fields	Field Description
96	PDU HEADER	Protocol Version - 8-bit enumeration
		Exercise ID - 8-bit unsigned integer
		PDU Type - 8-bit enumeration
		Protocol Family - 8-bit enumeration
		Time Stamp - 32-bit unsigned integer
		Length - 16-bit unsigned integer
		Padding - 16 bits unused
48	ENTITY ID	Site - 16-bit unsigned integer
		Application - 16-bit unsigned integer
		Entity - 16-bit unsigned integer
8	FORCE ID	8-bit enumeration
8	3 OF ARTICULATION	8-bit unsigned integer
	PARAMETERS (n)	
64	ENTITY TYPE	Entity Kind - 8-bit enumeration
		Domain - 8-bit enumeration
		Country - 16-bit enumeration
		Category - 8-bit enumeration
		Subcategory - 8-bit enumeration
		Specific 8-bit enumeration
		Extra - 8-bit enumeration
64	ALTERNATIVE	Entity Kind - 8-bit enumeration
	ENTITY TYPE	Domain - 8-bit enumeration
		Country - 16-bit enumeration
		Category - 8-bit enumeration
		Subcategory - 8-bit enumeration
		Specific 8-bit enumeration
		Extra - 8-bit enumeration

(continued on next slide)

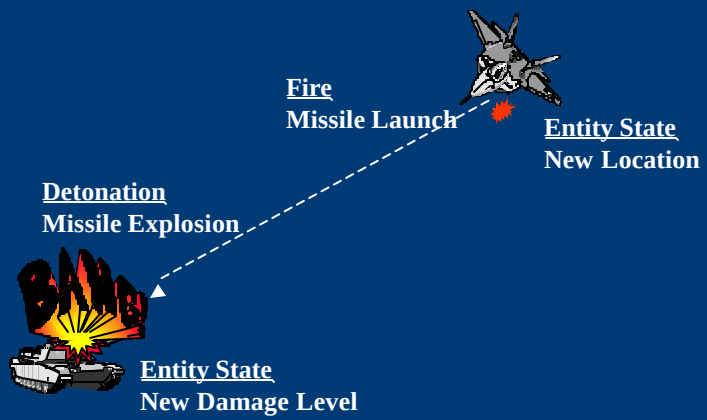
Entity State PDU (cont)

96	ENTITY	X Component - 32-bit floating point
	LINEAR	Y Component - 32-bit floating point
	VELOCITY	Z Component - 32-bit floating point
192	ENTITY LOCATION	X Component - 64-bit floating point
		Y Component - 64-bit floating point
		Z Component - 64-bit floating point
96	ENTITY	Psi - 32-bit floating point
	ORIENTATION	Theta - 32-bit floating point
		Phi - 32-bit floating point
32	ENTITY	32-bit record of enumerations
	APPEARANCE	
320	DEAD RECKONING	Algorithm - 8-bit enumeration
	PARAMETERS	Other Parameters - 120 bits unused
		Entity Linear Accel - 3X32-bit floating point
		Entity Angular Accel - 3X32-bit floating point
96	ENTITY	Character Set - 8-bit enumeration
32	MARKING	11 8-bit unsigned integers
	CAPABILITIES	32 Boolean fields
n X 128	ARTICULATION	Parameter Type Designator - 8-bit enumeration
	PARAMETERS	Change - 8-bit unsigned integer
		ID - attached to - 16-bit unsigned integer
		Parameter Type - 32-bit parameter type record
		Parameter Value - 64-bit

DIS PDUs

- Entity Information/Interaction
  - Entity State
  - Collision
- Warfare
  - Fire
  - Detonation
- Logistics
  - Service Request
  - Resupply Offer
  - Resupply Received
  - Resupply Cancel
  - Repair Complete
  - Repair Respond
- Distributed Emission Regeneration
  - Electromagnetic Emission
  - Designator
- Radio Communication
  - Transmitter
  - Signal
  - Receiver
- Simulation Management
  - Start/Resume
  - Stop/Freeze
  - Acknowledge
  - Action Request
  - Action Response
  - Data Query
  - Set Data
  - Data
  - Event Report
  - Message
  - Create Entity
  - Remove Entity

DIS PDU Operations



PDU Volumes

1993 I/ITSEC Demonstration with 79 Nodes

Entity State	96%
Other	4%
Fire	4%
Detonation	4%
Collision	1%
Logistics	0%
Sim Mgt	0%
Emission	38%
Transmitter	50%
Signal	0%
Acoustic	2%
Stealth	1%
Others	0%

Aggregate Level Simulation Protocol

- Application of SIMNET and DIS principles to constructive simulations
- Synchronized advance of simulation time
- Adherence to common object model
- Object ownership and control