



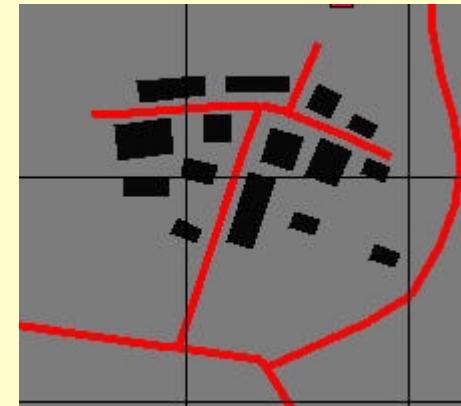
Real-Time, Pseudo-Randomly Generated Features for Combat Experimentation in Urban Sprawl

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Need for Urban Sprawl Representation

- Operations Other Than War
- Military Operations in Urban Terrain
- Peacekeeping
- Domestic Preparedness
- Homeland Defense
- Military/Civilian Partnerships



Live events in urban/suburban areas are rarely an option

Urban Sprawl Adds Realism

- Line-of-sight obstructions
- Mobility barriers / trafficability
- Serendipitous firing positions
- Civilian and commercial considerations
- Interior / exterior engagements
- Target acquisition clutter



Ubiquitous throughout an expansive battlespace

Urban Sprawl Problem Space

Unofficial definitions:

Urban: Billions and billions of objects

Sprawl: ...and they keep going, and going, and going

A *Fact* usually ignored in simulation:

All buildings have interiors



The problem complexity of these 3 dimensions of urban sprawl approaches a 3rd Order Infinity

Shortfalls of Traditional Approaches

As terrain database complexity $\rightarrow \infty$,
development schedule $\rightarrow \infty$,
cost $\rightarrow \infty$,
simulation performance $\rightarrow \emptyset$,
ratio of detail used per event $\rightarrow \emptyset$.

Military Solution:
Limited number of databases,
re-used exhaustively,
R&D towards faster/cheaper,
**cannot catch up
with need**

Gaming Solution:
Limits player choices,
movie set approach,
R&D towards prettier,
**cannot meet military
requirement for freeplay**

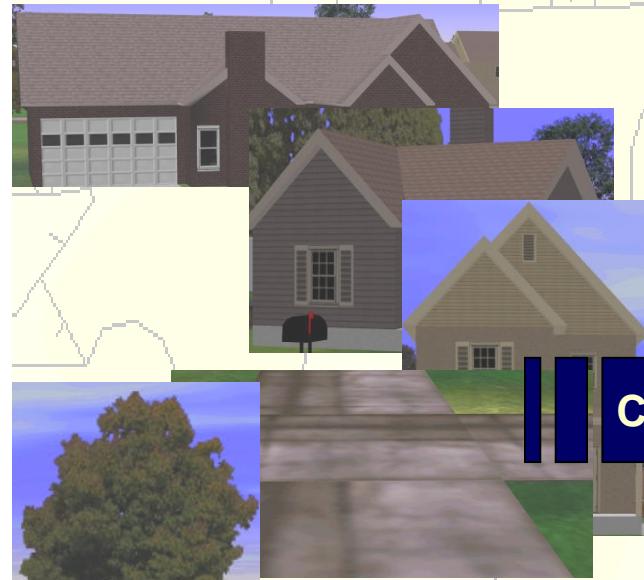
The Conceptual Model



Gutenberg (1398-1468)

a	a	ā	ā	ā	ā	ā
b	b	b̄	b̄	c	c	c
d	d	d̄	d̄	d̄	d̄	d̄
ē	ē	ē̄	ē̄	f	f	f
h	h	h̄	h̄	h̄	h̄	h̄
j	j	j̄	j̄	j̄	j̄	j̄
o	o	ō	ō	p	p	p

Movable Type



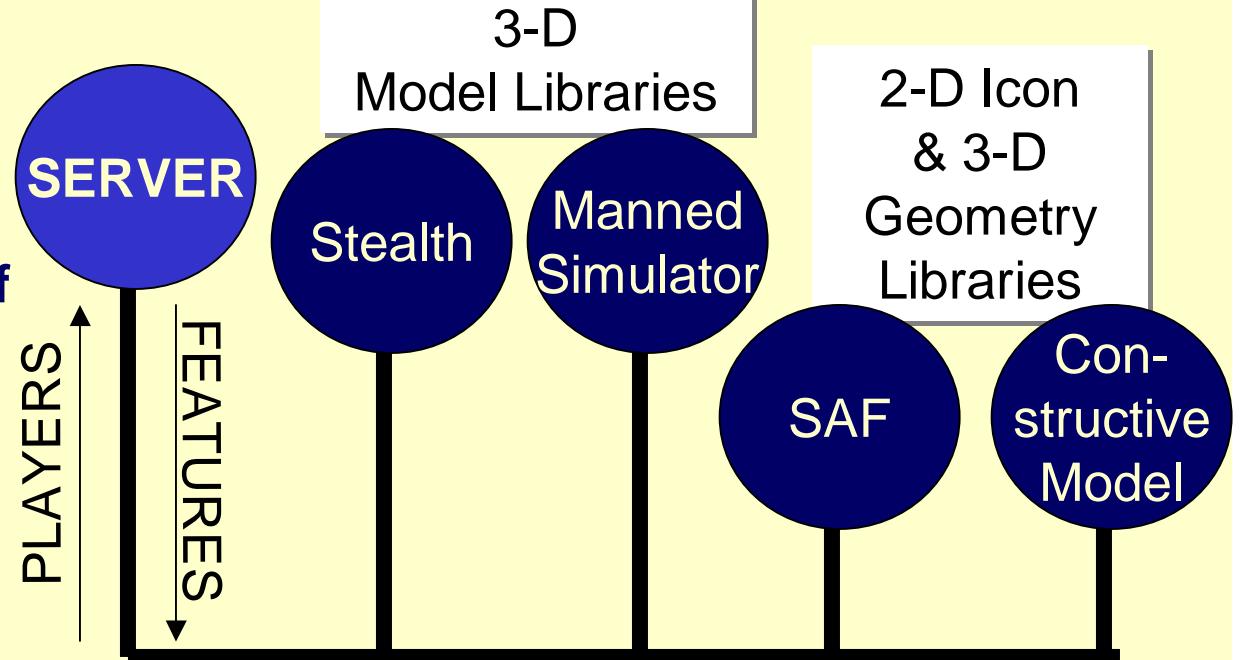
Cultural Features

Quis eretur tui ut dñe nisi ihesu xpi y sua festissima et pessima miserae et absolucionis et remissionis in vita
apologo ad ac dñe apostola misericordia et miserae regni et absolutionis ab omnibz peccatis suis. Etiam absolutionis et remissionis in vita
et exercitio et amissione et angustie debetur quatinusque peccatis. Sed aplice reuekans et lectorum a quibusdam contumaciam suspensus et in exercitu
illius fons et fontis et pennis et calixtus a jure peccati ab hoc symboleto si quis inveniatur dando nos plenaria et omni peccatis nostris indul-
gentia et remissionem. Inquit enim clavis sancte matris ecclesie in hac parte se extendit. In nomine patens et filii et spiritus sancti amon-

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Service Interfaces

- Server subscribes to player entity locations
- Server publishes feature entity states in vicinities of player entities
- Clients use internal model libraries to instantiate features superimposed onto terrain



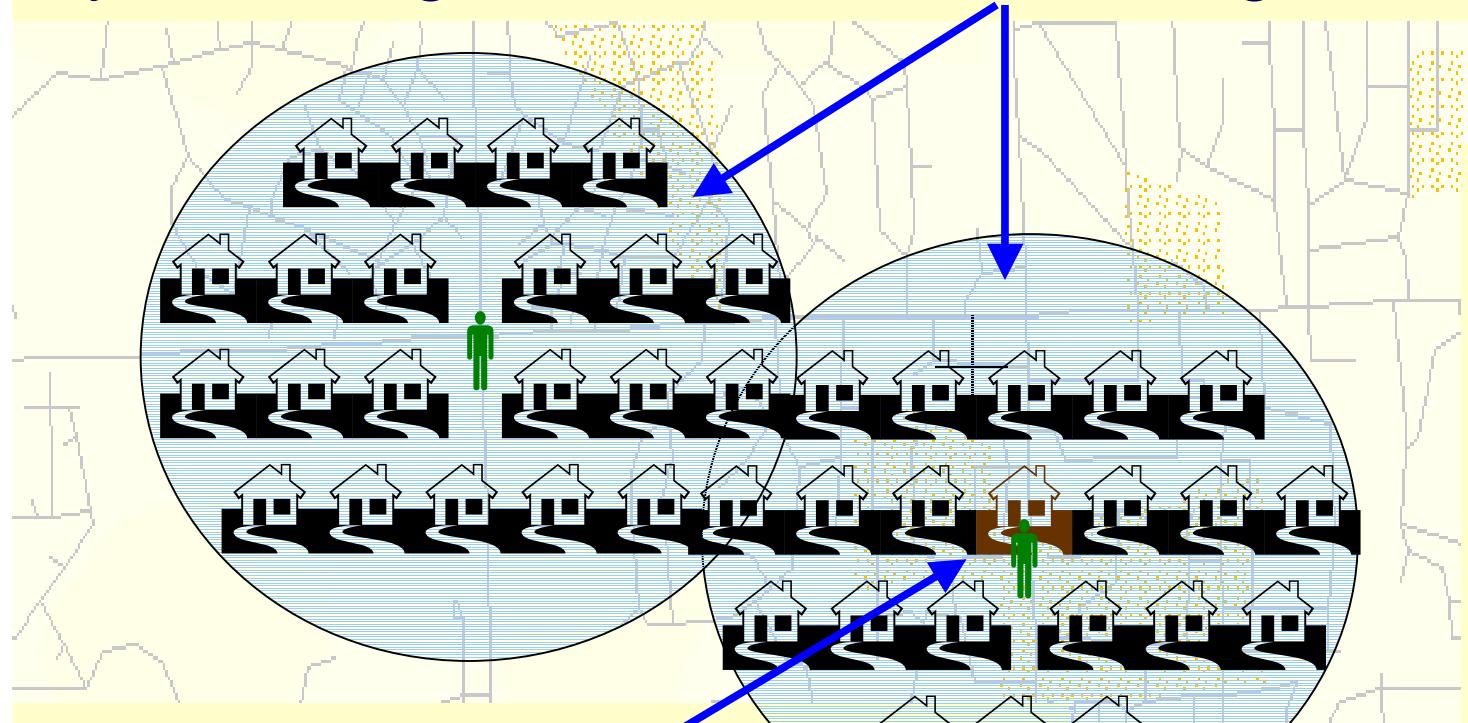
DIS: Rapid interoperability with legacy simulations
HLA: More control of feature data distribution

Real-Time Generation (decides *when* features are rendered)

SERVER

CLIENT

Dynamic regions for cultural feature generation



Interiors
of structures generated
in immediate player vicinities

Simulation
runtime
not
burdened
with
unobserved
detail



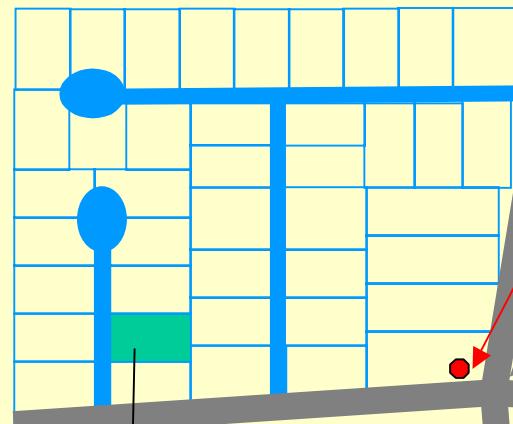
Pseudo-Random Rule Set

(decides *what* features are rendered *where*)

Suburban Example

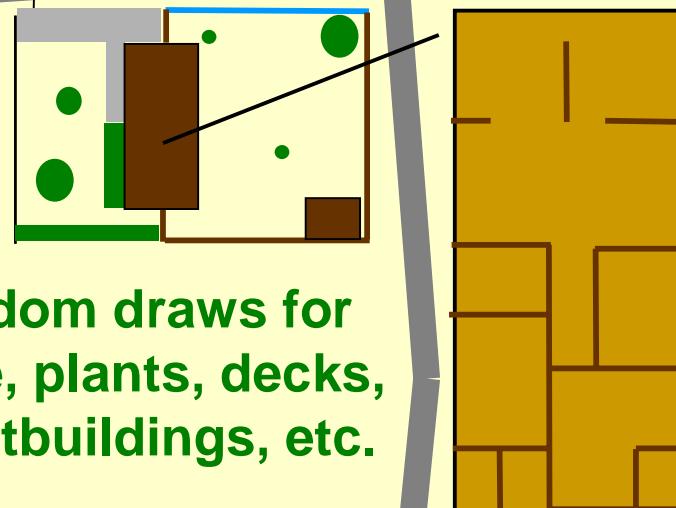
- Rule set for virtual suburban zoning
- Random number seed for each grid zone repeatably determines feature mix
- Building interiors generated by template as players approach

Rule 3: Quarter-block template for lot layout



Rule 2: Utility and sign entities at regular positions

Rule 1: Intersection offset to break up line-of-sight



Rule 4: Random draws for house, fence, plants, decks, driveway, outbuildings, etc.

Rule 5:
Selection of interior wall template per house dimensions

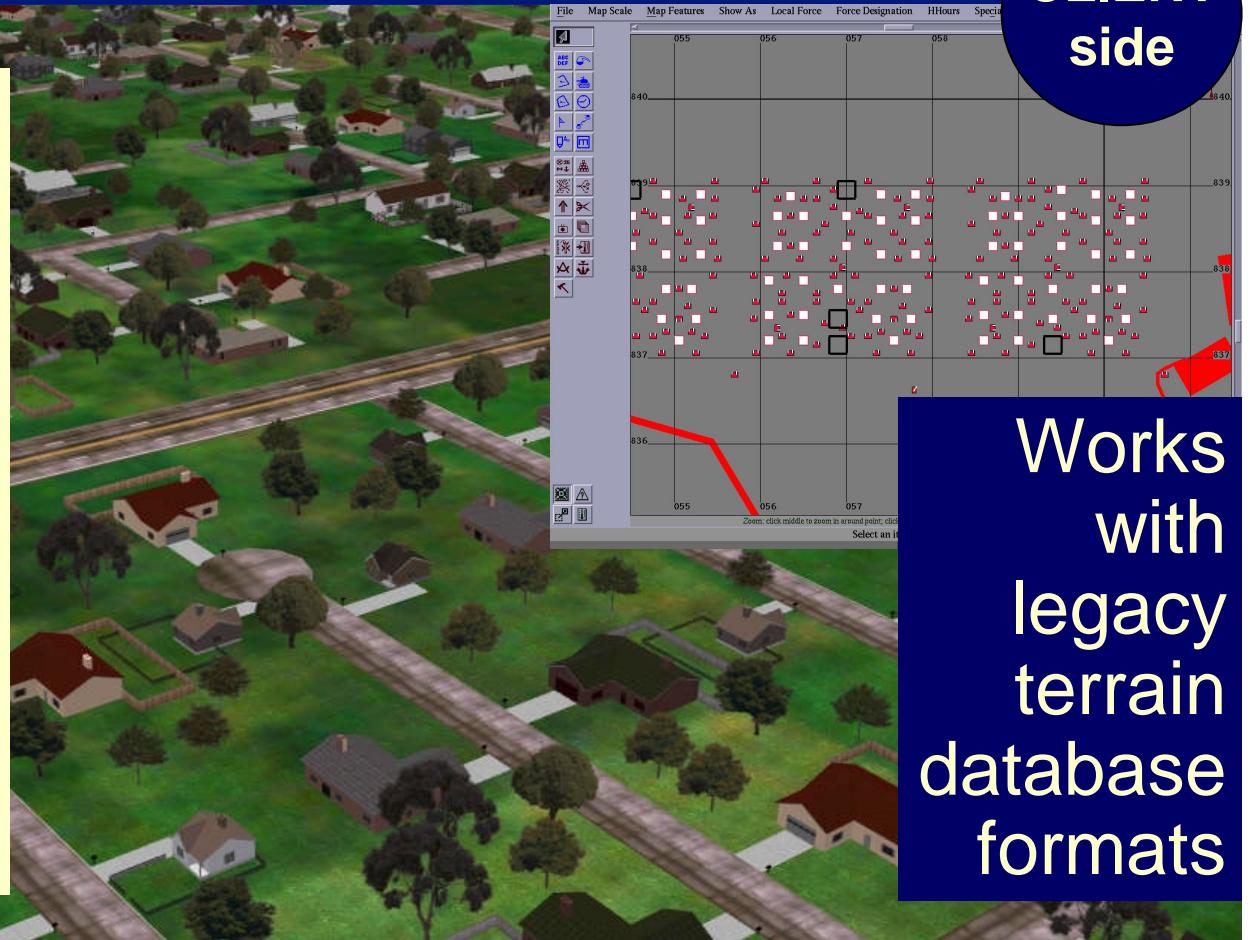
Cultural Feature Model Set

(decides *how* features are rendered)

CLIENT
side

Suburban Example

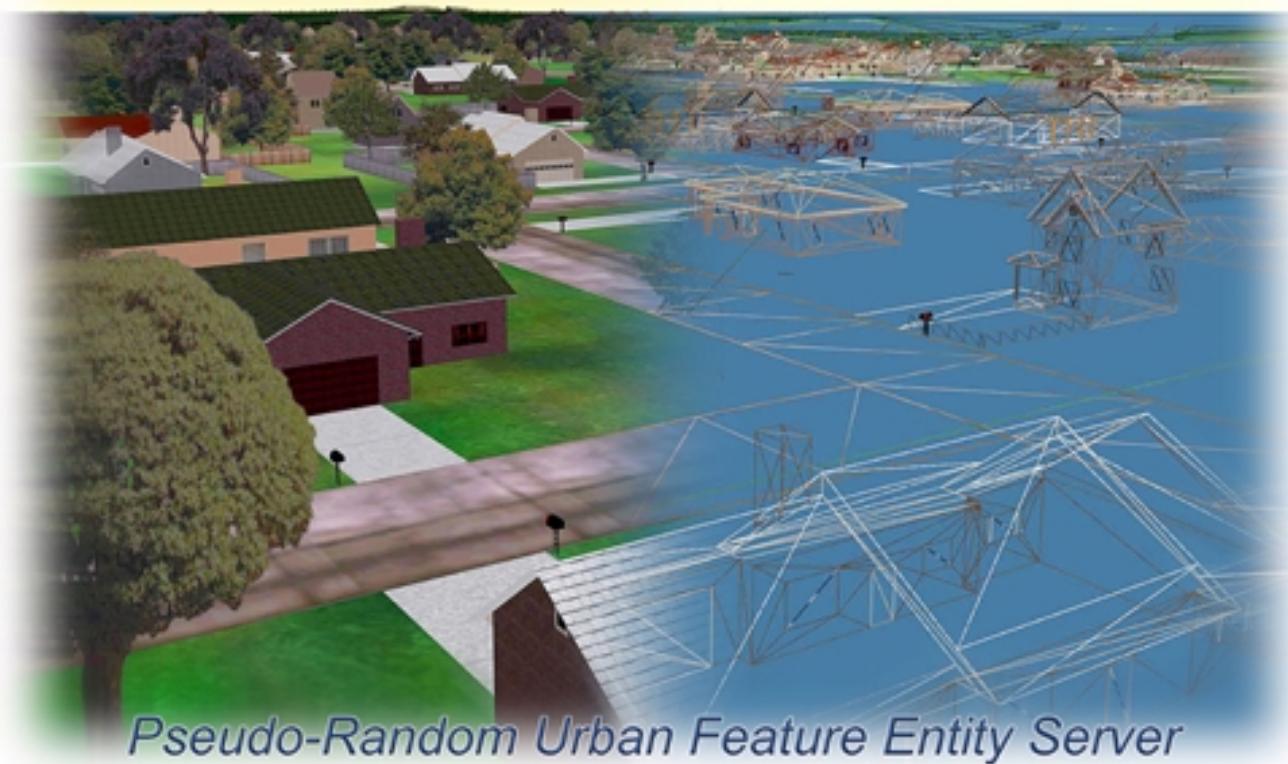
- Houses
- Streets
- Driveways
- Signs
- Fences
- Mailboxes
- Outbuildings
- Trees
- Shrubs
- Hedges
- Parked Cars
- etc...



Minimize number of individual models, but
Maximize variety and realism of scene

PRUFES: A Prototype Application

PRUFES



Pseudo-Random Urban Feature Entity Server

PRUFES Design Goals

Develop a prototype cultural feature server that:

- represents a typical American suburb
- is plug-n-play with legacy distributed simulations
- is limited to flat or ground-clamped terrain regions
- supports any user-defined x,y dimensions
- includes “Open Flight” format 3-D model sets
- includes interior structures
- generates and publishes features real-time as needed



PRUFES Innovations

(Minimize Models/Maximize Variety)

Appearance bits used to provide variable textures of each model



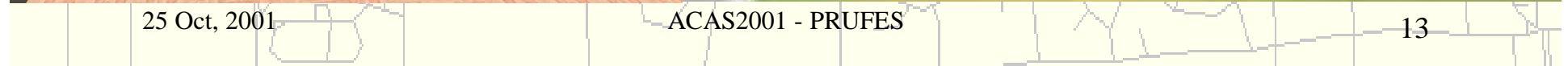
Textured interiors provide variety to internal building structure



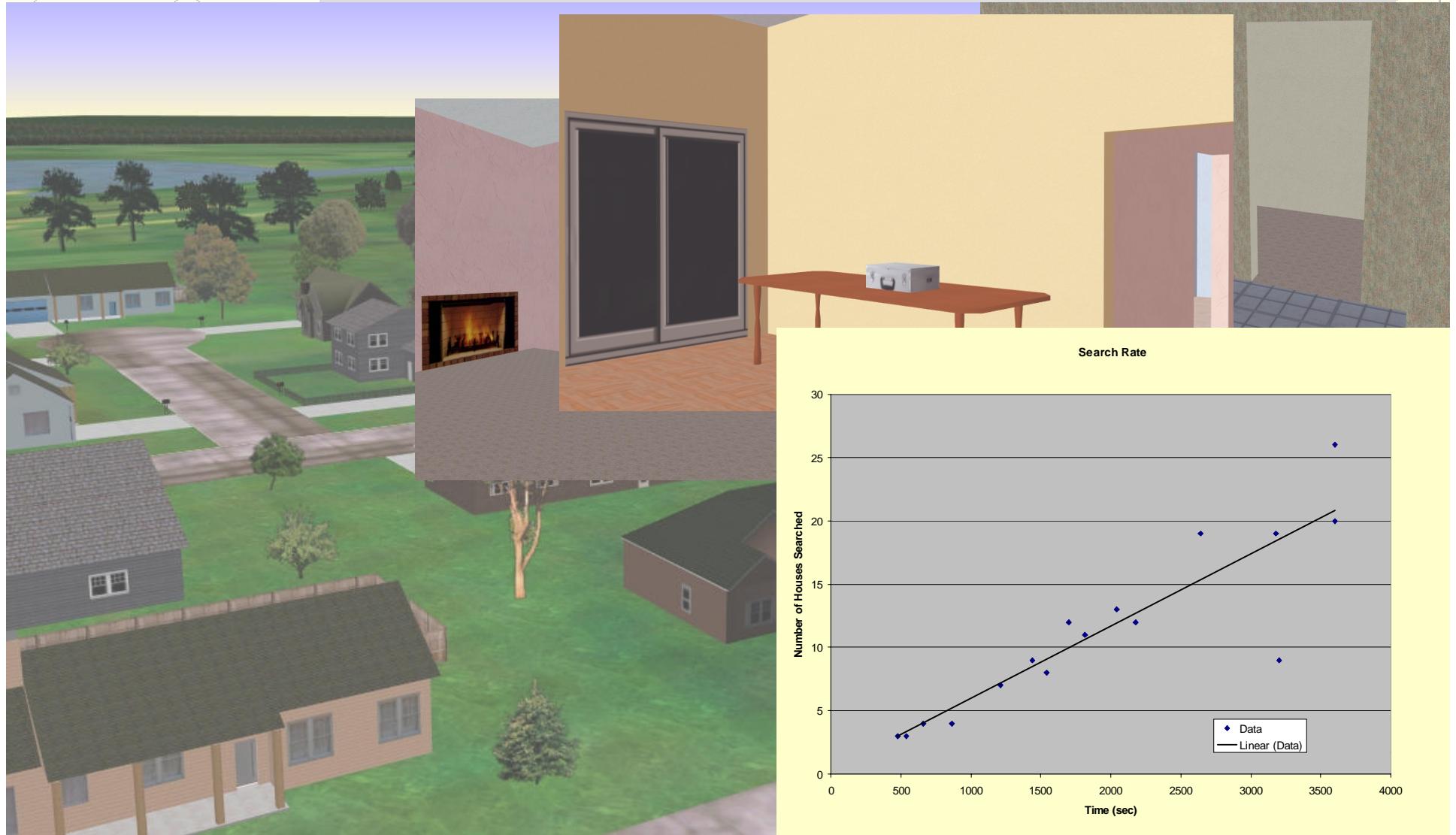
Articulated signs provide unique street names and numbers with a single model



“Baby Gate” articulated fences provide variable length with a single model



HomeLand Security Experiment



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Feature Server Integration Issues

File Map Scale Map Features Show As Local Force Force Designation HHHours Special Privilege



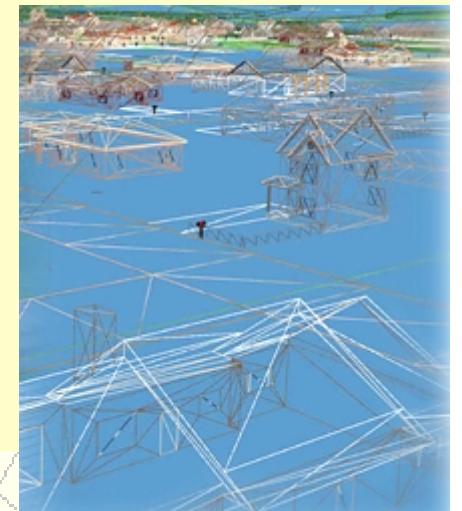
Some client simulations:

- Will not accept new model sets or enumerations
- Will not accept / recognize cultural entities
- Will not interact properly with cultural entities
- Use bounding volume, precluding internal structure
- Do not include entities in line-of-sight calculations
- Cannot extend time-out for static entities
- Cannot tolerate large entity counts

These issues are not universal nor insurmountable,
Many legacy manned simulators are plug-n-play

Potential Future Development

- More rule / model sets = more sprawl types
- More scene complexities
- User-defined tuning of rules during runtime
- Elevation / orientation algorithms for sloped terrain
- Interspersing built-in and real-time features
- Native HLA interfaces
- Non-static cultural entities
- Geo-specific data sets
- Real-time feature damage / alteration
- Complex, multi-story internal structure
- Nested fidelity for furniture, contents



For More Information

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