

World Growth & Construction System Design

Version: 1.1.0

Status: Draft

Last Updated: 2025-12-13

Dependencies: Energy Spire System, Tunnel System, Crafting Pipeline

Change Log:

- v1.1.0 (2025-12-13): Added Transfer Toll System (Section 3.4), Traffic-Based Sustainability (Section 6.4)
 - v1.0.0 (2025-12-07): Initial draft
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1. System Overview

Design Philosophy

The world network is a living organism that grows through sustained player activity and contracts through neglect. Players don't directly create worlds - instead, they nurture network conditions that cause worlds to emerge organically. Maintenance is an active, strategic endeavor rather than passive tax.

Core Principles

1. **Genesis Anchor:** The origin world is immortal and serves as the network's root
2. **Connectivity Required:** Every world must maintain a tunnel path to Genesis
3. **Emergent Growth:** Worlds spawn based on network energy flow, not player commands

4. **Active Decay:** Tunnels degrade without player-supplied charging units
5. **Cascade Risk:** Disconnected worlds face destruction after grace period
6. **Tiered Investment:** Consumables for maintenance, structures for efficiency, rare items for protection

Network Vitality Metaphor

The network breathes in cycles:

Phase	Description
Expansion	Active players push frontiers, new worlds crystallize
Plateau	Maintenance matches decay, stable network
Contraction	Activity drops, outer worlds collapse inward
Recovery	Returning players find smaller but healthy core
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2. Charging Unit Hierarchy

2.1 Tier 1: Fuel Cells (Consumable)

The baseline maintenance unit. Accessible to all players, consumed on use.

Crafting Recipe

Component	Amount	Notes
Energy Points	4	100 packets compressed to 4 points
Tetrahedron	1	4 points → speed shape
Color Affinity	Optional	Matches tunnel color for +25% bonus
Total Cost	~200 raw packets	+ crafting time
Output	1 Fuel Cell	

Fuel Cell Properties

Property	Value	Notes
Instant Charge	+10%	Applied immediately on deposit
Sustained Charge	+2%/hour	Lasts 24 hours
Total Charge Value	+58%	Over full 24-hour duration
Color Match Bonus	+25%	If fuel frequency matches tunnel color
Stack Limit	10	Max fuel cells active per sphere

Usage Flow

1. Player approaches Distribution Sphere
2. Opens Sphere Interaction UI

3. Selects "Deposit Fuel Cell"
 4. Chooses fuel cell from inventory
 5. Fuel cell consumed
 6. Charge applied to associated Quantum Tunnel
 7. Visual: Energy pulse travels up spire to ring
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2.2 Tier 2: Amplifier Structures (Permanent)

Permanent structures that multiply fuel cell efficiency. One per Distribution Sphere.

Crafting Recipe

Component	Amount	Notes
Dodecahedron	1	12 points → energy shape
Icosahedron	1	20 points → quantum shape
Packets	200	Must match tunnel frequency
Total Cost	~1,000 raw packets	equivalent
Output	1 Quantum Amplifier	placed immediately

Amplifier Properties

Property	Value	Notes
Fuel Efficiency	1.5x multiplier	All fuel cells at this sphere
Placement Limit	1 per sphere	Cannot stack amplifiers
Durability	Permanent	Does not decay
Destruction	Only on world collapse	Cannot be manually removed
Transfer	Not possible	Bound to sphere on creation

Amplified Fuel Cell Values

Property	Base	With Amplifier
Instant Charge	+10%	+15%
Sustained Charge	+2%/hour	+3%/hour
Total Value (24h)	+58%	+87%

Visual Representation

The amplifier adds a visible hexagonal frame structure around the Distribution Sphere. It glows brighter when fuel cells are active. Structure from bottom to top:

Element	Description
World Surface	Circuit Base platform
Energy Conduit	Vertical connector
Amplifier Frame	Hexagonal frame (NEW)
Distribution Sphere	Inside the frame
Quantum Tunnel Ring	Top, rotating

2.3 Tier 3: Quantum Stabilizer (Rare)

Rare protective structure that prevents tunnel collapse below a threshold.

Crafting Recipe

Component	Amount	Notes
Icosahedra	3	60 points total → quantum mastery
Blue Packets	500	Highest tier frequency
Magenta Packets	100	Quantum entanglement color
Prerequisite	Active amplifier	On target sphere
Crafting Time	1 hour	Cannot leave sphere during craft
Total Cost	~3,000 raw packets	equivalent
Output	1 Quantum Stabilizer	

Stabilizer Properties

Property	Value	Notes
Minimum Charge Floor	50%	Tunnel cannot decay below this
Placement Limit	1 per world	Strategic choice of which tunnel
Durability	Permanent	Until world destruction
Decay Prevention	Partial	Still decays TO 50%, not below
Emergency Reserve	Yes	World cannot isolate if stabilized tunnel exists

Strategic Implications

- A stabilized tunnel guarantees world connectivity (if other end connects to Genesis)
- Creates "backbone" routes that define network structure
- High cost means only critical infrastructure gets stabilized
- Losing a world with stabilizer is major setback

Visual Representation

The stabilizer adds 3 floating crystalline nodes around the tunnel ring. The crystals pulse in synchronized pattern with a blue-magenta energy field visible between them.

3. Tunnel Decay System

3.1 Base Decay Rates

Tunnels decay at rates based on current charge level:

Charge Range	State	Decay Rate	Time to Next Tier
80-100%	Stable	-0.5%/hour	40 hours
50-79%	Weakening	-1.0%/hour	29 hours
20-49%	Critical	-2.0%/hour	15 hours
1-19%	Failing	-3.0%/hour	6 hours
0%	Collapsed	N/A	Immediate

Decay Calculation

Effective Decay = Base Decay - Fuel Contribution

Example 1: Stable tunnel, 1 fuel cell active

Factor	Value
Base Decay	-0.5%/hour
Fuel Cell	+2.0%/hour
Net	+1.5%/hour (tunnel charging)

Example 2: Critical tunnel, no fuel

Factor	Value
Base Decay	-2.0%/hour
Fuel Cell	+0.0%/hour
Net	-2.0%/hour (tunnel failing)

3.2 Visual Decay States

State	Tunnel Beam	Ring Effect	Audio	UI Warning
Stable	Bright, steady	Smooth rotation	Ambient hum	None
Weakening	Slight flicker	Occasional stutter	Intermittent static	Yellow indicator
Critical	Heavy flicker	Erratic rotation	Warning pulse	Orange + alert
Failing	Cuts in/out	Sparking, unstable	Alarm tone	Red + screen flash
Collapsed	No beam	Ring stops, dims	Collapse sound	"TUNNEL LOST"

3.3 Tunnel Collapse Event

When a tunnel reaches 0% charge:

Time	Event
T+0	Collapse Initiated - Beam flickers rapidly for 5 seconds
T+3s	Final energy discharge (particle burst)
T+5s	Ring rotation stops, material shifts to dark/inactive
T+5s	Tunnel marked inactive in database
T+5s	Both connected spheres update state
T+5s	Network connectivity recalculated
T+5s	If world isolated: Begin isolation protocol

3.4 Transfer Toll System

When players transfer resources between worlds, a portion is consumed as tunnel fuel. This creates self-sustaining trade routes while frontier tunnels still require manual maintenance.

Toll Calculation (Hybrid Model)

Component	Base Rate	With Amplifier
Minimum Toll	1 packet	1 packet
Percentage	+2% of transfer	+1% of transfer
Maximum Cap	10 packets	5 packets

Toll Examples

Transfer Size	Base Toll	With Amplifier	Effective Rate
10 packets	1 (minimum)	1	10% / 10%
50 packets	2 ($1 + 1$)	1 ($1 + 0.5$ rounded)	4% / 2%
100 packets	3 ($1 + 2$)	2 ($1 + 1$)	3% / 2%
200 packets	5 ($1 + 4$)	3 ($1 + 2$)	2.5% / 1.5%
500 packets	10 (capped)	5 (capped)	2% / 1%

Charge Conversion

Each toll packet consumed adds **+0.15% tunnel charge**, distributed 50/50 to both tunnel endpoints.

Toll Packets	Charge Added	Per Endpoint
1	+0.15%	+0.075% each
5	+0.75%	+0.375% each
10	+1.5%	+0.75% each

Multi-Hop Transfers

Transfers crossing multiple tunnels pay toll at each hop. This encourages route optimization and investment in direct connections.

Route	Hops	Example Toll (100 packets, no amplifiers)
A → B	1	3 packets (97 arrive)
A → B → C	2	$3 + 3 = 6$ packets (94 arrive)
A → B → C → D	3	$3 + 3 + 3 = 9$ packets (91 arrive)

Transfer Types Subject to Toll

Transfer Type	Toll Applied?	Notes
Player inventory → Other world	Yes	Standard toll
Storage device → Other world	Yes	Standard toll
Player → Player (same world)	No	Local transfers free
Player → Storage (same world)	No	Local transfers free
Orb extraction	No	Mining has separate costs

Tunnel Requirements

Tunnel State	Transfer Allowed?
Active (80%+)	Yes
Weakening (50-79%)	Yes (with warning)
Critical (20-49%)	No - "Tunnel unstable"
Failing (1-19%)	No - "Tunnel failing"
Collapsed (0%)	No - "No connection"

Overflow Handling

When a tunnel is at 100% charge, toll packets are still collected but excess charge is banked (up to +20% reserve). This reserve depletes before normal decay begins.

4. World States & Lifecycle

4.1 World States

State	Description	Transitions To
Dormant	Exists at lattice position, not active	Crystallizing
Crystallizing	Spawning animation (1 hour)	Active
Active	Normal operation	Isolated

State	Description	Transitions To
Isolated	24-hour grace period, no Genesis path	Collapsing OR Active (if rescued)
Collapsing	Destruction sequence	Dormant

4.2 World Spawning (Crystallization)

Worlds emerge based on network conditions, not player commands.

Main Grid World Spawn

Conditions:

Requirement	Value
Adjacent active worlds	2+
Combined tunnel traffic	> 500 packets/hour
Sustained duration	6+ hours continuously
Target coordinates	Empty (no active world)

Spawn Process:

Step	Event
1	"Resonance Detected" notification to nearby players
2	Crystallization visual begins at empty coordinates
3	1-hour spawn timer
4	World becomes ACTIVE

Initial State: 26 dormant spires, 6 cardinal tunnels at 50% charge (connected to triggering worlds), base orb spawn rate active

Face-Center World Spawn

Conditions:

Requirement	Value
Surrounding main-grid worlds	4+ ACTIVE
Combined energy flow	> 1,000 packets/hour
Sustained duration	12+ hours
Amplifier requirement	All 4 surrounding worlds have amplifiers on facing spheres

Spawn Process:

Step	Event
1	"Quantum Convergence" event notification
2	Face-center position begins crystallization
3	2-hour spawn timer (more complex structure)
4	World becomes ACTIVE

Initial State: 26 dormant spires, 4 tunnels at 60% charge, +25% processing efficiency bonus

Cube-Center World Spawn (Super-Hub)

Conditions:

Requirement	Value
Surrounding worlds (cube vertices)	8 ACTIVE
Face-center worlds in region	4+ ACTIVE
Network-wide energy flow	> 10,000 packets/hour
Stabilizer requirement	2+ among surrounding worlds

Spawn Process:

Step	Event
1	"Quantum Nexus Forming" server-wide announcement
2	Dramatic crystallization (visible from surrounding worlds)
3	6-hour spawn timer
4	World becomes ACTIVE

Initial State: 26 spires (all pre-activated), up to 14 tunnels at 80% charge, +50% routing efficiency, unique "nexus" visual style

4.3 World Isolation Protocol

When a world loses all active tunnel connections to Genesis:

Isolation Timeline

Time	Event	Effects
T+0:00	ISOLATION DETECTED	"ISOLATION WARNING" broadcast; Skybox begins red tint (gradual over 1h); World marker orange on map; 24h grace period begins
T+6:00	FIRST WARNING	"18 HOURS UNTIL COLLAPSE"; Orb spawn rate → 50%; Ambient audio shifts tense
T+12:00	CRITICAL WARNING	"12 HOURS REMAINING"; Orb spawn rate → 0%; Surface visual degradation (cracks, energy leaks); Storage devices flash warning; Free evacuation teleport unlocked
T+18:00	FINAL WARNING	"EVACUATION RECOMMENDED: 6 HOURS"; Ground tremors (visual + camera shake); Emergency storage transfer available (50% loss); Sky fully red with ominous particles
T+23:00	IMMINENT COLLAPSE	"COLLAPSE IMMINENT: 1 HOUR"; Intense effects (lightning, discharge); Auto-evacuation begins at T+23:30; Final countdown displayed
T+24:00	WORLD DESTRUCTION	All players teleported to nearest connected world; Collapse animation (spires explode, sphere implodes, shockwave); All storage destroyed (contents lost); World → DORMANT; Network map updates

4.4 World Rescue

At any point during isolation grace period:

Rescue Conditions (any one):

- Restore any tunnel to 80%+ charge that connects to Genesis-linked world

- Another world's tunnel TO this world reaches 80%+
- New world crystallizes adjacent AND connects

Rescue Effects:

- Immediate exit from isolation state
 - All warnings clear
 - Skybox returns to normal (1-hour transition)
 - Orb spawning resumes
 - "WORLD RESCUED" celebration notification
 - Participating players receive "Savior" achievement/bonus
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5. Network Connectivity System

5.1 Connectivity Graph

The network is a graph where:

Element	Represents
Nodes	Active worlds
Edges	Active tunnels (80%+ charge)
Root	Genesis world (always connected)

Connectivity Check Algorithm:

1. Build graph from active worlds and tunnels
2. Run BFS/DFS from Genesis
3. Mark all reachable worlds as "connected"
4. Any unmarked active world enters ISOLATED state

Frequency: Every tunnel state change + every 5 minutes

5.2 Path Redundancy

Worlds with multiple paths to Genesis are more resilient:

Paths to Genesis	Resilience	Risk Level
1 path	Low	High - single tunnel failure = isolation
2 paths	Medium	Moderate - can lose one route
3+ paths	High	Low - significant redundancy

UI Indicator Example

World Info Panel:

Field	Value
World	Cardinal East (1,0,0)
Status	ACTIVE
Paths to Genesis	2
Route 1	Direct: Cardinal East → Genesis (98% charge)
Route 2	Via South: Cardinal East → Face-Center → Cardinal South → Genesis
Risk Level	<div style="display: flex; align-items: center;"> MODERATE </div>

5.3 Critical Path Identification

System identifies and highlights critical infrastructure.

Definition: A CRITICAL TUNNEL is one whose failure would isolate 1+ worlds

Example Network:

Genesis —— A —— B —— C, with B also connected to D

Critical Tunnels in this example:

Tunnel	Worlds Isolated if Failed
Genesis↔A	A, B, C, D
A↔B	B, C, D
B↔C	C
B↔D	D

UI: Critical tunnels shown with special indicator. Encourages players to build redundant routes.

6. Economic Balance

6.1 Maintenance Cost Analysis

Single Tunnel Maintenance (No Amplifier)

Factor	Value
Goal	Maintain tunnel at 80%+ (Stable state)
Decay	-0.5%/hour = -12%/day
Fuel Cell Value	+58%/24h effective
Break-even	~0.21 fuel cells/day
Practical	1 fuel cell every 4-5 days for stability
Cost per week	~2 Fuel Cells = ~400 raw packets

Single Tunnel with Amplifier

Factor	Value
Amplifier Cost	~1,000 packets (one-time)
Amplified Fuel Value	+87%/24h effective
Break-even	~0.14 fuel cells/day
Practical	1 fuel cell every 7 days for stability
Cost per week	~1 Fuel Cell = ~200 raw packets
Amplifier ROI	~5 weeks (saves 1 fuel cell/week)

World Maintenance Summary

World Type	Without Amplifiers	With Amplifiers
Minimum Viable (1 tunnel)	~400 packets/week	~200/week + 1,000 upfront
Standard (3 tunnels)	~1,200 packets/week	~600/week + 3,000 upfront
Hub (6 tunnels)	~2,400 packets/week	~1,200/week + 6,000 upfront

6.2 Stabilizer Economics

Factor	Value
Stabilizer Cost	~3,000 packets equivalent
Effect	Tunnel stays at 50%+ (never collapses)
At 50%	Decay -1%/h, fuel cell +2%/h net = easy maintenance
Value	Insurance against player absence

Best Use Cases:

- Backbone routes between major hubs
- Single-path worlds (prevents isolation)
- High-traffic commercial routes
- Guild headquarters connections

6.3 Player Activity Scaling

Player Type	Mining Rate	Weekly Yield	Can Maintain
Solo (10h/week)	~50 pkt/hour	~500 packets	1-2 tunnels (no amplifiers)
Active (20h/week)	~100 pkt/hour	~2,000 packets	5-6 tunnels (with amplifiers)
Guild (10 active)	Combined	~20,000 packets	Large network segment + multiple stabilizers

6.4 Traffic-Based Sustainability

Transfer tolls create a natural tier system where busy routes self-maintain while frontier tunnels require manual fuel cells.

Route Classification

Route Type	Daily Transfers	Daily Toll Packets	Daily Charge from Tolls
Trade Highway	200+	400+	+60%+ (self-sustaining)
Regional Route	50-200	100-400	+15-60% (partial support)
Local Connection	10-50	20-100	+3-15% (needs fuel cells)
Frontier Tunnel	<10	<20	<3% (full manual maintenance)

Self-Sustaining Threshold

A tunnel becomes self-sustaining when toll charge exceeds decay:

Tunnel State	Decay Rate	Toll Needed to Offset	Transfers Needed (avg 50 pkt)
Stable (80-100%)	-0.5%/hour = -12%/day	80 toll packets/day	~40 transfers/day
Weakening (50-79%)	-1.0%/hour = -24%/day	160 toll packets/day	~80 transfers/day

With Amplifier (toll reduced to ~1.5 avg per transfer):

Tunnel State	Transfers Needed
Stable	~55 transfers/day
Weakening	~110 transfers/day

Economic Scenarios

Scenario 1: High-Traffic Hub (100 transfers/day, avg 50 packets, with amplifier)

Factor	Value
Toll collected	~150 packets/day
Charge from tolls	+22.5%/day
Decay (stable)	-12%/day
Net	+10.5%/day (self-sustaining + surplus)

Scenario 2: Moderate Route (30 transfers/day, avg 50 packets, no amplifier)

Factor	Value
Toll collected	~60 packets/day
Charge from tolls	+9%/day
Decay (stable)	-12%/day
Net	-3%/day (needs ~1 fuel cell/week supplement)

Scenario 3: Frontier Tunnel (5 transfers/day, avg 30 packets, no amplifier)

Factor	Value
Toll collected	~5 packets/day
Charge from tolls	+0.75%/day
Decay (stable)	-12%/day
Net	-11.25%/day (needs full fuel cell maintenance)

Strategic Implications

- **Trade routes self-maintain:** Encourages commerce and specialization between worlds
- **Amplifiers on highways:** Clear ROI for investing in busy routes
- **Frontier requires commitment:** Expanding the network costs resources

- **Route optimization matters:** Shorter paths = less toll loss = more competitive prices
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7. Database Schema

7.1 New Tables

FuelCell Table

Field	Type	Notes
cell_id	u64 (PK, auto_inc)	Unique identifier
owner_identity	Identity	Player who crafted
frequency_color	String	"Red", "Green", "Blue", etc.
state	String	"Inventory", "Deposited", "Consumed"
deposited_sphere_id	Option	FK to DistributionSphere
deposit_time	Option	When deposited
expiry_time	Option	deposit_time + 24 hours
created_at	Timestamp	Craft time

QuantumAmplifier Table

Field	Type	Notes
amplifier_id	u64 (PK, auto_inc)	Unique identifier
sphere_id	u64	FK to DistributionSphere
world_coords	WorldCoords	World location
builder_identity	Identity	Player who built
built_at	Timestamp	Construction time
fuel_multiplier	f32	Default 1.5

QuantumStabilizer Table

Field	Type	Notes
stabilizer_id	u64 (PK, auto_inc)	Unique identifier
sphere_id	u64	FK to DistributionSphere
world_coords	WorldCoords	World location
builder_identity	Identity	Player who built
built_at	Timestamp	Construction time
charge_floor	f32	Default 0.5 (50%)

WorldState Table

Field	Type	Notes
world_coords	WorldCoords (PK)	World identifier
state	String	"Dormant", "Crystallizing", "Active", "Isolated", "Collapsing"
crystallization_start	Option	When spawn began
isolation_start	Option	When isolation detected
collapse_time	Option	Scheduled destruction
paths_to_genesis	u32	Redundancy count
last_connectivity_check	Timestamp	Last graph update
total_energy_routed	u64	For spawn calculations

NetworkEdge Table

Field	Type	Notes
edge_id	u64 (PK, auto_inc)	Unique identifier
source_world	WorldCoords	Origin world
target_world	WorldCoords	Destination world
tunnel_id	u64	FK to QuantumTunnel
is_active	bool	Charge $\geq 80\%$
is_critical	bool	Removal would isolate worlds

TunnelTraffic Table

Field	Type	Notes
traffic_id	u64 (PK, auto_inc)	Unique identifier
tunnel_id	u64	FK to QuantumTunnel
transfer_time	Timestamp	When transfer occurred
sender_identity	Identity	Player who initiated
packets_transferred	u32	Amount sent
toll_packets	u32	Amount consumed as toll
charge_added	f32	Charge % added to tunnel
source_world	WorldCoords	Origin
destination_world	WorldCoords	Destination
is_multi_hop	bool	Part of longer route

7.2 Modified Tables

QuantumTunnel (Extended Fields)

New Field	Type	Notes
last_decay_tick	Timestamp	Last decay calculation
active_fuel_cells	u32	Count of deposited fuel cells
has_amplifier	bool	Cached for quick lookup
has_stabilizer	bool	Cached for quick lookup
charge_floor	f32	0.0 or 0.5 if stabilized

8. Reducers

8.1 Fuel Cell Reducers

Reducer	Parameters	Returns	Description
craft_fuel_cell	frequency_color: String	Result	Craft fuel cell from materials
deposit_fuel_cell	cell_id: u64, sphere_id: u64	Result	Deposit into distribution sphere
process_fuel_expiration	(none)	Result	Scheduled: expire old cells, returns count

8.2 Structure Reducers

Reducer	Parameters	Returns	Description
build_amplifier	sphere_id: u64	Result	Build amplifier on sphere
build_stabilizer	sphere_id: u64	Result	Build stabilizer (requires amplifier)

8.3 Decay & Network Reducers

Reducer	Parameters	Returns	Description
process_tunnel_decay	(none)	Result	Scheduled every 5 min
update_network_connectivity	(none)	Result	Rebuild connectivity graph
process_world_states	(none)	Result	Handle state transitions
check_crystallization_conditions	(none)	Result	Check spawn triggers

8.4 Emergency Reducers

Reducer	Parameters	Returns	Description
emergency_evacuate	(none)	Result	Teleport from isolated world
emergency_storage_transfer	device_id: u64, destination: WorldCoords	Result	Transfer with 50% loss

8.5 Transfer Toll Reducers

Reducer	Parameters	Returns	Description
transfer_packets	destination: WorldCoords, packets: Vec<WavePacketSample>	Result	Transfer with toll calculation
calculate_toll	packets: u32, tunnel_id: u64	TollResult	Preview toll without executing
get_route_toll	source: WorldCoords, destination: WorldCoords, packets: u32	RouteTollResult	Calculate multi-hop total toll

TollResult Structure

Field	Type	Notes
toll_packets	u32	Packets consumed as toll
packets_delivered	u32	Packets that arrive
charge_added	f32	Charge added to tunnel
has_amplifier	bool	Whether amplifier reduced toll

RouteTollResult Structure

Field	Type	Notes
hops	Vec<WorldCoords>	Route taken
total_toll	u32	Sum of all hop tolls
final_delivery	u32	Packets arriving at destination
per_hop_toll	Vec<u32>	Toll at each hop

9. Unity Integration

9.1 New Components

WorldNetwork/

Component	Purpose
NetworkConnectivityManager.cs	Tracks paths to Genesis
WorldStateVisualizer.cs	Skybox, warnings, effects
CrystallizationEffect.cs	World spawn animation
CollapseSequenceController.cs	World destruction sequence

ChargingUnits/

Component	Purpose
FuelCellManager.cs	Crafting, inventory, deposit
FuelCellVisual.cs	Inventory item visual
AmplifierVisualizer.cs	Placed amplifier rendering
StabilizerVisualizer.cs	Stabilizer crystal rendering
ChargeFlowEffect.cs	Energy pulse on fuel deposit

UI/

Component	Purpose
NetworkMapUI.cs	Graph visualization
TunnelHealthUI.cs	Per-tunnel status
IsolationWarningUI.cs	Full-screen warnings
WorldStateIndicator.cs	HUD element

Events/

Component	Purpose
NetworkEvents.cs	Connectivity change events
WorldStateEvents.cs	Isolation, crystallization events
ChargingUnitEvents.cs	Fuel/amplifier/stabilizer events

9.2 Visual Effects Prefabs

Crystallization/

- WorldFormingParticles.prefab
- CrystallizationShader.shader
- EnergyConvergenceBeams.prefab

Collapse/

- SpireExplosion.prefab
- WorldImplosion.prefab
- ShockwaveEffect.prefab
- CollapseDebris.prefab

TunnelStates/

- StableBeam.prefab
- FlickeringBeam.prefab

- CriticalBeam.prefab
- FailingBeam.prefab

ChargingUnits/

- FuelCellDeposit.prefab
 - AmplifierFrame.prefab
 - StabilizerCrystals.prefab
 - ChargeFlowPulse.prefab
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10. Implementation Phases

Phase 1: Fuel Cells & Basic Decay (Weeks 1-3)

- FuelCell table and reducers
- Fuel cell crafting UI
- Deposit interaction at Distribution Sphere
- Basic tunnel decay tick
- Tunnel visual states (stable/flickering/critical/failing)
- Tunnel collapse event

Phase 2: Amplifiers & Network Tracking (Weeks 4-6)

- QuantumAmplifier table and reducers
- Amplifier crafting and placement
- Amplifier visual (frame around sphere)

- WorldState table
- Network connectivity graph
- Path-to-Genesis calculation
- Critical tunnel identification

Phase 3: World Isolation & Destruction (Weeks 7-9)

- Isolation detection and state transition
- 24-hour grace period timeline
- Skybox/warning visual effects
- Emergency evacuation reducer
- Emergency storage transfer
- World collapse animation sequence
- World → Dormant state transition

Phase 4: Stabilizers & World Spawning (Weeks 10-12)

- QuantumStabilizer table and reducers
- Stabilizer crafting and placement
- Stabilizer visual (floating crystals)
- Charge floor enforcement
- World crystallization conditions
- Crystallization animation
- Dormant → Active state transition
- Network map UI

Phase 5: Polish & Balance (Weeks 13-14)

- Decay rate tuning

- Economic balance pass
 - Visual polish
 - Sound design integration
 - Achievement system integration
 - Tutorial/onboarding for new mechanics
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11. Open Questions

Gameplay

1. **Tunnel Directionality:** Are tunnels bidirectional for connectivity, or does each direction need separate maintenance?
2. **World Ownership:** Should the first player at a crystallizing world get special status/bonuses?
3. **Decay Pause:** Should decay pause when no players are online? (Prevents overnight collapse but reduces urgency)
4. **Guild Structures:** Can guilds pool resources for shared amplifiers/stabilizers?

Technical

5. **Scheduled Reducers:** How to implement 5-minute decay ticks? SpacetimeDB scheduled reducers or client-triggered?
6. **Connectivity Performance:** BFS on large networks - acceptable latency? Need caching strategy?
7. **Collapse Synchronization:** How to synchronize dramatic collapse sequence across all connected clients?

Balance

8. **Solo Viability:** Can a solo player meaningfully participate, or is this inherently guild-focused?
 9. **Early Game:** How do new players experience this before they can craft fuel cells?
 10. **Cascade Prevention:** Should there be any "circuit breaker" to prevent total network collapse?
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12. Appendix: Quick Reference

Crafting Recipes Summary

Item	Ingredients	Output
Fuel Cell	4 Energy Points + 1 Tetrahedron	1 Fuel Cell
Amplifier	1 Dodecahedron + 1 Icosahedron + 200 packets	1 Amplifier
Stabilizer	3 Icosahedra + 500 Blue + 100 Magenta packets	1 Stabilizer

Decay Rates Summary

Charge	State	Rate	Tunnel Lifetime (no fuel)
80-100%	Stable	-0.5%/h	160 hours
50-79%	Weakening	-1.0%/h	29 hours
20-49%	Critical	-2.0%/h	15 hours

Charge	State	Rate	Tunnel Lifetime (no fuel)
1-19%	Failing	-3.0%/h	6 hours

World Spawn Conditions Summary

World Type	Adjacent Active	Energy Flow	Sustain Time
Main Grid	2+	500 pkt/h	6 hours
Face-Center	4+	1,000 pkt/h	12 hours
Cube-Center	8+	10,000 pkt/h	24 hours

Transfer Toll Summary

Component	Base	With Amplifier
Minimum	1 packet	1 packet
Percentage	+2%	+1%
Cap	10 packets	5 packets
Charge per toll packet	+0.15%	+0.15%
Distribution	50/50 both endpoints	50/50 both endpoints

Route Self-Sustainability Thresholds

Tunnel State	Decay/Day	Transfers Needed/Day (avg 50 pkt)
Stable (no amp)	-12%	~40 transfers
Stable (with amp)	-12%	~55 transfers
Weakening (no amp)	-24%	~80 transfers