Metaverse Standards Forum
Metaverse Bookmarks

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Metaverse STANDARDS FORUM™

Use Case Title

Metaverse Bookmarks

Use Case Identifier

MSF2025-MEB-001

- Version 1.0
- Year of Release: 2025

Summary of Use Case

Description: A persistent, standardized method is required to find places and content across the metaverse, building upon conventional Uniform Resource Locators (URLs). This involves capable methods to enhance traditional URLs with spatial, temporal, and user-centric data (such as Point of View, device type, or preferred avatar settings) to accurately represent the user's intended state and location within both virtual and physical (Mixed Reality) spaces upon access.

Benefits:

- Enables precise, device-adaptive navigation to specific locations, objects, moments, or states across disparate virtual environments (e.g., 2D map on mobile vs. immersive 3D in VR), with seamless session resumption from the exact prior context
- Ensures cross-platform persistence and interoperability via standardized spatial URLs, creating a universal "common language" for linking and sharing across siloed metaverses
- Streamlines Mixed Reality integration by robustly anchoring digital overlays to real-world locations or objects for accurate, context-aware loading
- Facilitates deep personalization through embedded user preferences (e.g., language, accessibility settings, credentials, or default avatar/loadout)
- Supports temporal bookmarking to capture and recall dynamic or historical moments in time-based experiences
- Unlocks high-fidelity social sharing and collaboration, transporting friends or teams instantly to an identical, shared context with full state replication

Contributors and Supporters

- 3D Web Interoperability Working Group
- MSF Domains (Peer Review)
- Use Case Taskforce

Keywords

Spatial Bookmarking, Metaverse Navigation, Persistent Navigation, Cross-Platform Persistence, Spatial-Temporal Addressing, Viewpoint State Serialization, X3D Viewpoint, WebXR, OGC GeoPose, Declarative 3D (Dec3D), Interoperability, Federated Resources, Graceful Fallback, Temporal Bookmarking, Asset Portability, Digital Identity, Privacy and Consent, Cybersecurity, Collaborative Environments, Mixed Reality (MR) Anchoring

Actors/Entities

- **User in Virtual World**: Individual participant who accesses and navigates fully immersive digital environments via web browsers or XR devices, loading personalized avatars, assets, and preferences from cloud/decentralized storage to engage with virtual spaces, objects, and other users.
- **Place in Virtual World**: Defined spatial context or scene within a virtual environment, encompassing geometry, physics, interactive elements, and metadata (e.g., scale, lighting, permissions) that anchors user navigation, object placement, and multiplayer synchronization across devices.
- **User in Physical + Augmented World**: Participant blending real-world presence with digital overlays in mixed/augmented reality sessions, using device sensors (e.g., camera, GPS, SLAM) to anchor interactions while maintaining physical visibility and collaborative alignment with co-located others.
- **Place in Physical + Augmented World**: Hybrid anchor point fusing real-world coordinates (e.g., geofenced locations or scanned geometry) with virtual content layers, enabling persistent, shared digital placements (e.g., AR overlays, MR furniture) that adapt to user devices and environmental changes for consistent, location-aware experiences.

Detailed Description of Use Case/Scenario

Preconditions:

1. **Profile & Data Portability**
   - User possesses authenticated, portable profile with secure cloud/decentralized storage
   - Preferences, credentials, and bookmark data are retrievable and shareable across platforms
2. **Standards & Platform Capabilities**
   - Platform implements spatial URL standards encoding location, temporal, and user state data
   - Services support state serialization, temporal snapshots, collaborative access, and conflict resolution
3. **Context Discovery**
   - System can detect environmental context (virtual coordinates, timestamps, physical anchors)
   - Accurate mapping of bookmark loading across different environments
4. **Privacy, Permissions & Consent**

- User privacy settings and consent selections enforceable during bookmark sharing and access
- Verifiable credentials for link access control

5. **Persistence and Sharing Rules**
   - Rules defined for bookmark retention (ephemeral vs. permanent, public vs. private)
   - Integration with social APIs for embedding bookmarks in posts and media
6. **Performance & Accessibility**
   - Bookmarks optimized for quick activation with progressive loading
   - Accessibility flags and fallbacks for incomplete data

Main Flow:

- **Scenario 1:** Social Gallery Bookmarking & Sharing

1. Henry navigates to metaverse art gallery and finds exhibition worth saving
2. Activates bookmark function, capturing spatial coordinates, environmental state, and user context
3. System automatically attaches metadata (gallery name, exhibition title, nearby artworks)
4. Henry adds personal notes and selects privacy settings for sharing
5. Bookmark generates shareable link integrated with his profile
6. Henry shares via messaging; friends receive rich preview
7. Friends click link and system reconstructs exact viewpoint and state
8. Participants join synchronized instance with consistent environment
9. Session ends with bookmark persisting in Henry's profile

- **Scenario 2:** Temporal Bookmarking for Past Events

1. Connor attends live concert in virtual venue
2. Bookmarks peak moment with temporal flag, capturing timestamp and environmental state
3. System attaches contextual metadata (artist, setlist, crowd metrics)
4. Connor adds personal context and saves as highlight reel
5. Shares bookmark via social media
6. Later activation reconstructs concert environment from historical data
7. Friends access link and experience archived state
8. Bookmark evolves with post-event updates

- **Scenario 3: Contextual Sharing from Screenshots**

1. Connor screenshots musical-themed metaverse location
2. System auto-generates contextual bookmark with location metadata
3. Metadata embedded in image file or associated link
4. Connor posts screenshot with integrated bookmark
5. Alice clicks embedded link and loads adapted view
6. System applies accessibility adjustments for Alice's needs
7. Alice saves customized version to her profile

- **Scenario 4: Location-Aware Historical Layering**

1. Sue visits physical location and loads history experience
2. Bookmarks location with temporal parameters and hybrid anchors
3. System associates historical data layers across time periods

4. Sue activates bookmark and navigates through temporal layers
5. MR display overlays historical reconstructions on physical space
6. Progressive detail loading based on user focus
7. Sue saves multi-layer stack and shares with others

- **Scenario 5: Collaborative Custom World Invites**

1. Madison designs custom 3D party space
2. Bookmarks complete setup with layout and access controls
3. Generates shareable link with synchronized state
4. Friends join and load exact environment simultaneously
5. Real-time collaborative edits and updates
6. Bookmark evolves during session
7. Final state saved as template for future use

Alternative Flow

- **Scenario 1 Alternatives:** Social Gallery Bookmarking & Sharing

1. **Exhibition No Longer Available**
   - A friend clicks Henry's shared bookmark, but the specific exhibition has been removed or replaced:
     - The system detects the missing or altered primary environment.
     - Instead of failing, it loads the user into the gallery's main lobby or a designated "archive hall."
     - It presents a clear message: "The original exhibition has evolved. You are in the current main gallery, which contains similar artworks."
     - It offers an option to view an archived, static snapshot of the exhibition as Henry saw it, labeled as a "Historical View."
2. **User Lacks Permissions for Shared Space**
   - A friend clicks the link, but the gallery is now in a private event mode or requires a new membership the friend doesn't have:
     - The system authenticates the user and identifies the permission barrier.
     - It does not load the main environment. Instead, it displays a rich preview mode (360° panoramic view, video walkthrough, or 3D object viewer) populated from the bookmark's metadata.
     - It provides a clear call-to-action: "Request access from Henry" or "Purchase a membership to enter."
3. **Instance is Full**
   - Multiple friends click the link simultaneously, attempting to join a synchronized instance that has a user cap:
     - The system places incoming users in a queue or waiting lobby.
     - It provides their position in the queue and estimated wait time.
     - It offers an alternative to join a parallel, non-synchronized instance of the same space immediately, with a message: "Join a live view now, or wait to join Henry's group."

- **Scenario 2 Alternatives: Temporal Bookmarking for Past Events**

1. **Incomplete Historical Data**

- Connor activates his concert bookmark, but the system's archival data for crowd density or specific lighting effects is corrupted or partial:
  - The system loads the core, stable elements (stage setup, main audio track, base lighting
  - For missing dynamic elements (e.g., crowd avatars, fog), it uses procedural generation or AI interpolation to create a plausible reconstruction, based on available data.
  - It visually indicates which elements are "approximated" through a subtle UI marker or tutorial tip.

2. **Creator/Platform Replay Restrictions**
   - Connor tries to share or access the bookmark, but the artist or platform has disabled replay functionality for the event:
     - The system blocks the loading of the temporal environment.
     - It presents a curated, static "after-show" page instead, which may include official photos and videos from the concert and a link to the artist's page or future events.
3. **Context Mismatch on Replay**
   - A friend loads the concert bookmark but has a strong preference for a different avatar type, causing a perceptual clash**:**
     - The system detects the potential avatar mismatch for the historical context.
     - Upon loading, it offers a one-time option: "Optimize your avatar for this historical event?" which may apply temporary adjustments for consistency.

- **Scenario 3 Alternatives:** Contextual Sharing from Screenshots

1. **Screenshot Lacks Sufficient Metadata**
   - Connor takes a screenshot, but the system cannot determine the precise location:
     - The system fails to auto-generate a precise spatial bookmark.
     - It instead creates a "Generic Metaverse Link" attached to the image, which points to the general platform or district where the screenshot was taken.
     - It prompts Connor to manually tag the screenshot with a destination.
2. **Recipient's Platform Incompatibility**
   - Alice clicks the embedded link in Connor's post, but she is on a device or platform that is entirely incompatible with the source metaverse:
     - The link opens a web page that displays the screenshot and a descriptive summary generated from the bookmark's metadata.
     - The page provides clear instructions and links for how Alice *can* access the space.
3. **Privacy Filtering on Share**
   - Connor's screenshot includes other users or private text chats in the background:
     - Before finalizing the post, the system's privacy layer automatically analyzes the screenshot and attached bookmark data.
     - It blurs or omits avatars of users who have not consented to public sharing.
     - It alerts Connor that some elements have been hidden for privacy.

- **Scenario 4 Alternatives:** Location-Aware Historical Layering

1. **GPS/SLAM Localization Failure**
   - Sue tries to activate her historical bookmark downtown, but the device cannot get a precise GPS lock or SLAM tracking fails:
     - The system cannot anchor the historical layers to the physical world.
     - It offers a fallback "Floating Map" mode where historical layers are displayed on a semi-transparent 2D/3D map that Sue can manipulate manually.
2. **Conflicting Historical Data**
   - Sue is viewing the "colonial" layer, but new archaeological research has superseded the model attached to her bookmark:
     - The system detects the version mismatch between her saved bookmark and the current authoritative data.
     - It loads the experience but displays a subtle indicator: "Historical model updated."
     - It offers Sue a toggle to choose between the original and the updated model.
3. **Physical Obstruction or Safety Hazard**
   - Sue's bookmark places a historical overlay directly onto a physical space that is now occupied by a construction site or a busy road:
     - Using up-to-date map data, the system recognizes the area as unsafe or inaccessible.
     - It automatically re-projects the historical layer to a safe, nearby vantage point.
     - It displays a warning that the view has been adjusted for safety.

- **Scenario 5 Alternatives:** Collaborative Custom World Invites

1. **Bookmark Creation Fails Due to Complex Assets**
   - Madison attempts to bookmark her custom world, but some imported assets have compatibility restrictions or are too large to serialize.
     - The system identifies the problematic assets and provides Madison with a detailed report.
     - It offers to automatically replace restricted assets with compatible equivalents from the platform's library.
     - For oversized assets, it suggests optimization or provides cloud-hosted alternatives.
     - Madison can approve these changes or manually resolve each issue before bookmark generation.
2. **Join Failure Due to Version Mismatch**
   - Friends try to join using Madison's bookmark, but their client software is running an incompatible version:
     - The system detects the version mismatch during the handshake process.
     - Instead of failing, it automatically redirects users to a compatibility layer that streams the experience via web browser.
     - It provides clear messaging about the version issue and instructions for updating.

- Users in the streamed mode have limited interaction capabilities but can still participate.

3. **Real-Time Edit Conflicts During Collaboration**
   - Multiple friends simultaneously attempt to edit the same DJ booth controls, causing conflicting commands.
   - The system implements an immediate conflict resolution protocol:
     - For audio controls: establishes a queue system or voting mechanism
     - For structural edits: creates temporary edit zones with ownership flags
   - Visually highlights conflicting edits and notifies all participants
   - Provides an "undo conflict" option and establishes clear edit permissions
4. **Network Instability During Synchronized Session**
   - Madison's internet connection becomes unstable during the collaborative editing session:
     - The system detects the degrading connection and automatically switches to a hybrid sync mode.
     - Critical changes are queued locally with conflict markers.
     - Other participants see Madison's avatar as "updating" rather than frozen.
     - Upon reconnection, the system performs automatic state reconciliation with manual resolution for any irreconcilable conflicts.
5. **Access Control Violation Attempt**
   - An uninvited user attempts to join using a shared or leaked bookmark link.
     - The system verifies user credentials against the bookmark's access controls.
     - Unauthorized users are redirected to a waiting room or preview area.
     - Madison receives a notification with the option to grant temporary access or permanently block the user.
     - All authorized participants are notified of the access attempt.
6. **Resource Limits Exceeded During Session**
   - The collaborative edits cause the world to exceed platform resource limits (e.g., polygon count, simultaneous users).
   - The system automatically optimizes the environment by:
     - Reducing LOD (Level of Detail) on distant objects
     - Implementing object culling for non-essential elements
     - Limiting particle effects and complex shaders
   - Notifies all participants of the optimization with an option to revert non-critical changes.
   - Provides Madison with upgrade options for extended resources.
7. **Session Recovery After Unexpected Disconnect**
   - The host (Madison) loses connection unexpectedly, potentially corrupting the evolving bookmark state:
     - The system automatically promotes another participant to temporary host.
     - Creates a recovery checkpoint and continues the session.

- When Madison reconnects, she can resume host privileges with the option to revert to her last known state or accept the current session state.
- All changes during the recovery period are logged for review.

Postconditions

1. **Bookmark Persistence & Version Control**
   - Created bookmarks with full metadata (spatial coordinates, temporal data, environmental state, user context) are committed to persistent storage and linked to the user's cross-platform profile.
   - Temporal bookmarks maintain versioned associations with historical data sources, with clear indicators of data freshness and update availability.
2. **Privacy & Consent Enforcement**
   - All sharing and access activities respect the original creator's privacy settings and consent preferences, with automated enforcement across all shared instances.
   - Any mid-session changes to privacy or consent settings are immediately propagated to active participants and retained in the user's profile for future bookmark activations.
3. **State Reconciliation & Conflict Resolution**
   - Server-side reconciliation verifies consistency for all persisted bookmark states and resolves any residual conflicts from collaborative sessions according to predefined resolution rules.
   - For temporal bookmarks, the system validates data integrity against authoritative historical sources and flags any discrepancies for user review.
4. **Accessibility & Personalization Persistence**
   - User-level accessibility settings and comfort preferences (navigation modes, text scaling, audio descriptions) applied during bookmark experiences are retained and automatically applied to future activations.
   - Device-specific optimizations are logged and associated with the user's profile for consistent cross-device experiences.
5. **Audit & Security Logging**
   - Event logs capture critical operations: bookmark creation, sharing activities, access attempts, temporal reconstructions, collaborative edits, and conflict resolutions.
   - Security logs track authentication events, permission changes, and access control decisions, with all logs respecting privacy and data retention policies.
6. **Recovery & Session Continuity**
   - For collaborative bookmarks (e.g., real-time edits in Madison's party setup), recovery checkpoints are automatically stored at defined intervals, enabling session resumption with minimal data loss in case of unexpected disconnections.
   - Version history is maintained for evolving bookmarks, allowing users to revert to previous states or fork from specific points in time.
7. **Analytics & System Improvement**
   - Platform analytics aggregate anonymized telemetry on bookmark usage patterns, popular locations, sharing frequency, and reconstruction success rates.

- Performance metrics track loading times, cross-platform compatibility, and user engagement to drive continuous system optimization while maintaining user privacy.

Implementations and Demonstrations or Technical Feasibility

Implementations and Demonstrations

- **Dec3D (Declarative 3D), X_ITE and X3D (X-Freedom):** X3DOM and X_ITE open-source frameworks enable integrating X3D as HTML5 DOM elements, rendered via WebGL. They demonstrate how 3D scenes can be declaratively added to web pages, manipulated via DOM APIs, and support WebXR for immersive viewing. These implementations specifically showcase the use of X3D's Viewpoint and OrthoViewpoint nodes for spatial bookmarking. The X3D standard defines a mechanism where a specific camera view can be referenced by a URL fragment, following the format someURL/AScene.x3d#ViewpointName. In practice, within frameworks like X3DOM, this is implemented by binding a named Viewpoint node in the scene graph, which the runtime then activates when the fragment is detected, providing a working model for persistent navigation points.
- **WebXR with Standards Integration:** WebXR provides a universal API for accessing VR/AR hardware, used by engines like Unreal. Runtimes exist for major platforms (Oculus, SteamVR, Windows Mixed Reality). Community plugins enable WebXR export for Unity and Unreal. This ecosystem now integrates with spatial standards like Open Geospatial Consortium (OGC) GeoPose for precise real-world anchoring and W3C Media Fragments for temporal addressing, enabling comprehensive spatial-temporal bookmarks that work across immersive and non-immersive devices.
- **Industrial and Enterprise Platforms**: Industrial metaverse platforms (for e.g. **Nvidia Omniverse**, and **Siemens Immersive Engineering**) focus on professional collaboration, data visualization, and digital twins, often using open standards for asset compatibility and interoperability. These platforms demonstrate practical implementations of persistent spatial contexts through USD (Universal Scene Description) composition and W3C POI (Points of Interest) extensions, showing how complex industrial environments can maintain consistent spatial references across sessions and users.
- **Standards-Based Bookmarking Prototypes:** Emerging implementations combine W3C Media Fragments for temporal indexing with X3D Viewpoint nodes for spatial context, creating unified spatial-temporal bookmarks. For example, prototypes demonstrate bookmarks like factory.usdz#t=120.5&view=AssemblyStation that captures both a specific time in a process and a precise 3D viewpoint, enabling accurate recreation of collaborative contexts.

Technical Feasibility:

- **X3D Viewpoint for Spatial Bookmarks:** Using X3D's Viewpoint node to define bookmarks is a direct and standardized approach. The path from specification to implementation is clear, with open-source examples showing how to embed and interact with 3D scenes in web browsers, providing a solid foundation for a declarative bookmarking system. The technical maturity of X3D's named camera Viewpoint nodes demonstrates the immediate feasibility for implementing persistent spatial references across sessions, as conceptualized by the standard’s URL fragment syntax.

- **OpenXR for Cross-Platform Consistency**: Solves the critical problem of hardware fragmentation, ensuring that navigation and input can work consistently across different VR/AR devices. This makes it highly feasible to build a cross-platform system where a bookmark can reliably restore a session state, regardless of the user's specific headset. The widespread adoption of OpenXR by major hardware vendors confirms the technical viability of consistent spatial experiences across diverse devices.
- **Standards Integration Feasibility:** The technical feasibility of combining **W3C Media Fragments** for temporal addressing with **OGC GeoPose** for spatial precision is demonstrated through existing web standards compatibility. These specifications are designed for web-native implementation and can be integrated with X3D Viewpoint nodes to create comprehensive spatial-temporal bookmarks that work across different metaverse platforms and devices.
- **BMW Group's Factory Digital Twins:** Used across 31 factories to simulate and optimize production lines, enabling real-time collaboration on a shared, persistent digital twin. This effort could be extended to support "bookmarks", where a specific viewpoint of a factory bottleneck, sharing a configured robot cell state, or marking a specific revision of the layout for a design review could be saved.
- **Siemens & Sony NX Immersive Designer**: Allows global teams to collaborate in real-time on high-fidelity product designs using VR and precise 3D model manipulation. Engineers could use bookmarks to save and share specific design perspectives, assembly steps, or issue locations within a complex product model.
- **Somnium Space**: As a VR-native persistent world, it offers deep world-building tools. The ability to save and return to specific, immersive locations created by users—such as private homes, galleries, or meeting spots—is a key feature of its environment.

Challenges:

- **Unified Resource Routing Challenge:** Developing coherent and extensible schemes to support the addressing and marshaling of digital resources from multiple deep or federated service stacks. The challenge is to create protocols that seamlessly route and aggregate this distributed content without fragmentation or performance bottlenecks.
- **Resource Persistence Challenge:** Ensuring web-based resources endure beyond their initial hosting, as many vanish without archival interventions like the Internet Archive, leading to defunct addresses (e.g., 404 errors). This requires robust mechanisms for long-term discoverability and revival in a metaverse where transient content underpins shared experiences.
- **Adoption Barriers Challenge:** Overcoming structural barriers to metaverse acceptance, including legacy web artifacts that hinder seamless integration. The challenge involves transforming potential obstacles into enablers, fostering an ecosystem where outdated conventions accelerate rather than impede widespread participation.
- **Cookies and User Agents Challenge:** Addressing cookies and user agents as potential barriers (or opportunities) to metaverse adoption, where rigid tracking models clash with fluid, cross-platform identities. The challenge is to evolve these tools into privacy-respecting, interoperable signals that enhance personalization without eroding trust or complicating onboarding.

- **User Skepticism Challenge:** Mitigating user skepticism around bad links, pervasive surveillance, and phishing schemes in the metaverse. This demands transparent, verifiable systems that build confidence through auditable navigation, secure sharing, and fraud-resistant designs to encourage open exploration and collaboration.

Requirements:

Technical and Functional Requirements

- **Persistent Spatial-Temporal Addressing:** A technical mechanism is required to create, store, and resolve persistent addresses that encapsulate not only a 3D location but also a specific temporal state and user context (e.g., camera view, environment settings). This ensures users can reliably return to or share a precise moment and viewpoint within a dynamic metaverse experience.
- **Extensible Namespace Management:** Implementation must provide a standardized, yet extensible, method for organizing and resolving semantic namespaces for metaverse locations and content. This system must support hierarchical naming, user-defined tags, and cross-platform semantic resolution to enable intuitive discovery and organization of bookmarks beyond simple coordinates.
- **Graceful Address Parsing & Fallback:** The client-side system must be designed to parse complex spatial-temporal addresses gracefully. Clients must be able to interpret and render the components of an address they understand (e.g., basic 3D coordinates) while safely ignoring or providing a functional fallback for unrecognized or unsupported extended parameters (e.g., specific temporal states or advanced rendering settings), ensuring robust interoperability across different platform capabilities.
- **Viewpoint State Serialization:** The system must be capable of serializing and reconstructing the full state of a user's viewpoint, including camera position, orientation, field of view, and rendering parameters. This is critical for accurately recreating the intended visual context and composition of a bookmarked scene across different devices and sessions.

Interoperability Requirements

- **Cross-Platform Bookmark Persistence:** A standardized data format and API for metaverse bookmarks must function consistently across all platforms and devices. This is mandatory for supporting the concept of "persistent navigation," allowing a bookmark created on one device to be seamlessly accessed and activated from any other supported device.
- **Semantic Interoperability Protocol:** The standardized bookmarking protocols must, at least initially, support both low-level coordinate-based addressing and high-level semantic naming, ensuring broad utility for both technical systems and end-users while managing the complexity of mapping human-readable names to precise spatial-temporal states.

Other Key Considerations:

- **Privacy:** Privacy controls must specifically address the collection and storage of data embedded in spatial-temporal bookmarks, including viewpoint parameters, environmental states, and temporal context. Users must have granular control over what contextual data is saved and shared with their bookmarks.

- **Cybersecurity:** Cybersecurity measures must protect the entire bookmarking ecosystem, from the creation and storage of persistent addresses to their resolution and activation. This includes securing the data integrity of the bookmark itself, preventing tampering with spatial or temporal parameters, and safeguarding the associated user metadata against unauthorized access or theft.
- **Identity Verification:** Identity verification must be integrated into the sharing and access control of bookmarks, especially for private or gated locations. This ensures that only authorized users can resolve a shared link, preserving the security and exclusivity of the bookmarked environment or moment.
- **Networking and Latency:** Network and infrastructure optimization must account for the instant resolution of complex bookmarks, which may require loading significant historical or contextual data. Strategies such as predictive pre-fetching of assets and geographically distributed caching of persistent states are necessary to ensure low-latency access, regardless of a user's location.
- **Ownership:** Ownership controls must allow users to retain full sovereignty over the bookmarks they create. This includes the right to delete, edit, transfer, or revoke access to their persistent links, ensuring they maintain control over their curated pathways and shared contexts within the metaverse.
- **Digital Ethics:** Ethical standards must guide the implementation of bookmarking and namespace systems to prevent misuse, such as the non-consensual tagging of locations, the creation of persistent links to harmful content, or semantic naming that promotes bias or exclusion.
- **Provenance:** Provenance tracking is necessary for temporal bookmarks to maintain an immutable and verifiable record of a bookmarked state's origin and any subsequent changes. This provides a clear audit trail for the historical context of a saved moment and ensures the authenticity of the recreated environment.
- **Accessibility:** The system must adhere to accessibility standards by ensuring that the creation, organization, and retrieval of persistent addresses are usable by people with diverse abilities, supporting alternative input methods and providing audio or simplified visual cues for navigating saved locations.

Relevant Domain Working Group (WGs):

- Standards Registry
- 3D Asset Interoperability using USD and glTF
- Interoperable Characters/Avatars
- Digital Asset Management
- Real/Virtual World Integration
- Privacy, Cybersecurity and Identity
- Network Requirements and Capabilities

Relevant Pre-qualified Organizations and Groups (POGs):

- **W3C (World Wide Web Consortium):** Provides the essential standardization backbone for persistent metaverse navigation by developing the core web technologies—such as the WebXR Device API for immersive device access, the potential integration of concepts from Media Fragments for temporal addressing, and the DOM infrastructure that enables specifications like X3D's Viewpoint nodes to function as spatial bookmarks. This work is critical for ensuring that a saved spatial-temporal state can be reliably reconstructed and experienced across the diverse ecosystem of devices that constitute the metaverse.
- **X3DOM (X-Freedom)**: An open-source framework and runtime for 3D graphics on the Web. It can be freely used for non-commercial and commercial purposes, and is dual-licensed under MIT and GPL license.
- **Web3D Consortium:** An independent, member-driven organization that develops and promotes royalty-free, open ISO standards for 3D graphics and communication on the web. Its core standard, X3D (Extensible 3D), is critical for ensuring the functional and visual consistency of experience and long-term interoperability across diverse virtual environments.
- **Khronos Group:** An open, royalty-free consortium that develops standards for 3D graphics and XR. Its standards — including WebGL and OpenXR — enable consistency of experience by providing unified APIs for cross-platform 3D rendering directly in browsers (WebGL) and standardized input/output/spatial handling across diverse VR/AR hardware (OpenXR).
- **Fraunhofer IGD:** A leading international research institute for applied visual computing, driving innovation in interactive graphics technologies. Among its key contributions is the development of X3DOM, an open-source framework that seamlessly integrates 3D content into web pages as HTML5 DOM elements.

Relevant Specifications, Publications and Projects (SPPs):

- **WebXR Device API**: This W3C-standardized API is the critical enabler for cross-platform metaverse bookmarking, providing a unified interface to VR and AR hardware directly from web browsers. It allows a spatial bookmark to dynamically restore a user's immersive session state—including head position, controller inputs, and spatial context—across diverse devices, ensuring that a saved viewpoint in a virtual gallery or a collaborative space is experienced with high fidelity and consistent interaction, whether accessed from a desktop, a smartphone, or a VR headset.
- **W3C Media Fragments URI**: This W3C Recommendation provides the standardized syntax for temporal and spatial addressing within media resources. It allows a metaverse bookmark to extend beyond static location to include a precise moment in time, using a URI fragment (e.g., concert.x3d#t=30,45) to capture and replay a specific segment of a dynamic, time-based virtual event, such as a live performance or a historical reenactment.
- **X3D Viewpoint Node**: This ISO-standardized X3D component provides the native mechanism for defining and saving 3D camera states directly within a scene graph. It allows a spatial bookmark to capture and serialize a user's precise viewpoint—including 3D position, orientation, field of view, and descriptive label—enabling the creation of stable, shareable links (e.g., gallery.x3d#GrandEntranceView) that restore the exact visual perspective and composition for any user, on any compliant device.

- **Hubs (by the Hubs Foundation)**: This open-source platform, now community-maintained, is a premier example of a working 'spatial bookmarking' system, where each room has a unique, shareable URL that acts as a direct portal from a browser or VR headset.
- **VRSpace**: A fully open-source server and client project for hosting virtual worlds. It demonstrates key mechanics for a bookmarking system, such as providing persistent access to specific spaces via a URL and maintaining multi-user state synchronization.
- **OGC GeoPose**: Provides a practical, specification-ready standard for precise Earth-relative positioning in mixed reality environments. This standardized method encodes both position and orientation in real-world coordinates using a concrete JSON format, enabling metaverse bookmarks to accurately anchor digital content to specific geographic locations. By ensuring consistent spatial alignment across different platforms and devices, GeoPose directly supports reliable location-based bookmarking for both enterprise and consumer metaverse applications.

Related Use Cases

- Consistency of Experience (MSF2025-COE-001)

Additional Comments

- This document is a living artifact and may be subject to revisions on a periodic basis to reflect the future state of Metaverse Bookmarks, and or based on feedback received from MSF stakeholders that warrants an update in the future.