Dynamic Space Partitioning, Reservation, and Player Movement For Concurrent, Non-linear and Virtual Location-based Entertainment

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ABSTRACT

Location-based entertainment (LBE) using virtual reality (VR) is a type of group entertainment that is orchestrated in relatively large spaces, e.g., halls, repurposed malls, etc. LBE for VR typically has carefully-timed, linear, and inflexible content that is designed to rapidly pipeline players through the experience. Players typically have little control via their actions or decisions on the evolution of the game.

This disclosure describes techniques to dynamically partition a physical venue into regions, where regions are locked by players as they move around based on game content. Regions support branching, e.g., non-linear content such as multiple exits per region. The techniques enable LBE experiences with arbitrary duration and player agency. The usage of large physical spaces is optimized to support a large number of concurrent groups that can go through different VR experiences in a safe and systematic manner.

KEYWORDS

- Location-based entertainment
- Virtual reality
- Dynamic space partitioning
- Concurrent VR entertainment
- Branching content
- Non-linear game content
- Player agency
- VR arena
- Retail space
- Anchor store
BACKGROUND

Location-based entertainment (LBE) using virtual reality (VR) is a type of group entertainment that is orchestrated in relatively large spaces, e.g., halls, repurposed malls, etc. For example, a team of participants may play a game in a virtual environment, e.g., a spaceship, a pirate boat, etc., recreated in a large, physical venue. LBE for VR typically has carefully-timed, extremely linear, and generally inflexible content that is designed to rapidly pipeline players through the experience. Players typically have little control, via their actions or decisions, on the evolution of the game. LBE players are often compared to passengers on a VR ride.

While one team occupies a physical venue, other teams simply have to wait. Alternately, if multiple concurrent teams are to be supported in one physical venue, the multiple teams must traverse pre-divided, contiguous, static, and linear pathways (and content) through physical space. Paths of multiple teams playing concurrent but independent VR games cannot generally intersect. This not only reduces the throughput of a given venue, it also reduces the number of possibilities within a game. It is not feasible or safe to put everyone into a large physical space and hope the players don’t run into each other while each experiencing substantially different virtual environments.

DESCRIPTION

This disclosure describes techniques to dynamically partition a physical space into regions, where regions are locked by players as they move around based on game-content or business/venue-specific requirements. Regions support branching, e.g., non-linear content such as multiple exits per region (virtual room). The techniques enable experiences with arbitrary duration and player agency, usually not afforded to LBE experiences. Additionally, the large venues can be made cost-effective by increased concurrency by enabling redirected walking.
techniques that are not effective in smaller spaces. The techniques optimize the usage of large physical spaces to maximize the number of concurrent groups that can go through different VR experiences in a safe and systematic manner.

**Fig. 1: Multiple independent teams awaiting entry into a physical venue**

Fig. 1 illustrates multiple independent teams of players (shown in different colors) awaiting entry in a physical venue (the gray space). In practice, the physical venue can be, e.g., a large hall, a repurposed multi-story mall, etc. In the case of a physical venue that spans multiple stories, various features of the venue, e.g., columns, elevators, stairways, etc., can be incorporated into or demarcated away from virtual environments.

**Fig 2: The entry of a blue team into a demarcated region (A) of the physical venue**
Fig. 2 illustrates the entry of a single team (blue) into a demarcated region (A) of the physical venue. The blue team can be presented with a certain virtual environment, e.g., a spaceship, etc.

Fig. 3: The managed expansion of the blue team into the physical venue

Fig. 3 illustrates the managed expansion of the blue team’s region. The expansion can be heralded by certain virtual events, e.g., the opening of a virtual door, or in the spaceship virtual environment, the opening of a virtual wormhole that leads to a new space, etc.

Fig. 4: The ceding of a region (A) by the blue team to the magenta team, and the occupation of a new region (B) by the blue team
Fig. 4 illustrates the ceding of a region (A) by the blue team to the magenta team, and the occupation of a new region (B) by the blue team. The ceding of a region by a team to another can be heralded by certain virtual events, e.g., the closing of a virtual portal, a virtual cave-in, etc. The magenta team can be in a completely different virtual environment as compared to the blue team. For example, the magenta team can experience an ocean-going, pirate-boat virtual environment even as the blue team plays in a spaceship virtual environment.

![Fig. 5: Concurrent game-play by two independent teams in separated regions (magenta and blue) of the same physical venue](image)

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![Fig. 6: Concurrent, independent teams have been moved from their previous regions to occupy new regions](image)

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Fig. 6 illustrates the dynamic nature of concurrent game-play by independent teams. For example, each team has moved from its previous regions to occupy new regions. The change of regions for each team can be coordinated with changes in their respective virtual environments. For example, the spaceship team might be moved into a new physical region while players within virtually experience a movement into a new galaxy. Such movements can be non-linear, and need not be preordained. For example, depending on player decisions and game position, new regions for a team can open up in any adjacent free region, e.g., north, south, east, west, up, or down, with reference to the currently occupied region. This adds to the possibilities of complexity within a game.

![Image of concurrent game-play](image.png)

**Fig. 7: The entry of brown team into a region of the physical venue that is disjoint from regions occupied by the magenta and blue teams**

Fig. 7 illustrates the entry of yet another team, the brown team, into the physical venue. The space A, once occupied by the blue team, then occupied by the magenta team, is now ceded to the brown team. The space B, once occupied by the blue team, is now occupied by the magenta team. The brown team can operate in a virtual environment different from the blue and the magenta teams. For example, the brown team can experience a virtual battlefield.
Fig. 8: Three concurrent, independent teams occupying disjoint regions of a physical space

Fig. 8 illustrates three concurrent, independent teams that occupy disjoint regions of a physical space.

Fig. 9: Multiple, concurrent, independent teams occupying disjoint regions of a physical space, with their paths of evolution crisscrossing each other

In Fig. 9, multiple, concurrent, independent teams participating in an LBE experience occupy disjoint regions of a physical space. The arrows indicate the paths taken by each team to arrive at its present location. The intersection of the paths is indicative of the dynamic nature of space-partitioning and reservation entailed by the described techniques, e.g., a given region can be occupied, or re-used, by multiple different teams at distinct time slots. Although not explicitly
illustrated, a team can traverse multiple linear routes that negotiate locks on regions as game-
players move through. Also, a path can include branching options.

By partitioning the physical venue into reservable regions, and by providing a runtime
service that enables separate experiences (each running for a group of players) that lock a region
as players move through it, content can be configured to enable routes from region to region. A
previous region is released once everyone in a team has moved to a new region. The released
region then becomes available for other groups to reserve and move into.

Regions, or virtual rooms, are airlocked between each other. A virtual room can have
multiple exits that the players can choose between, or exits that are procedurally unlocked, e.g.,
become apparent only at higher levels of game accomplishment. If content were built as a series
of interconnected rooms as described, with some degree of rogue-like, semi-procedural content
(rooms that are configured for the reserved region, doors that open automatically, etc.), any
sufficiently large area can have its physical space optimized for use, enabling a large number
players to go through it concurrently without requiring simplistic, fixed-duration linear pipelines.

Players could influence the route and would have more agency, as expected in typical
video games, where player decisions and actions affect the experience. While linear routes
between rooms are possible, the described techniques support branching choices, driven by the
availability of adjacent regions, player decisions, design mechanics, business needs of the venue
(e.g., keep people moving), safety (e.g., maximize group separation to the extent possible), etc.

Groups that are moving slowly don’t block faster groups, since the faster group can
simply be routed around the slower group. Another benefit is that the entire space can be shared
by multiple types of experiences as long as they are all accessed by a shared region manager. A
repurposed anchor store of a mall can serve as a physical venue, with each of its several
entrances reconfigured thematically for the experience associated with a particular entrance. For example, one entrance can be a virtual space-port, where users embark on a virtual space flight through the repurposed anchor store, while another entrance can be a virtual sea-port, where users embark on virtual, ocean-going pirate boats.

Some design principles are listed below to enable dynamic space partitioning, reservation and player movement for concurrent, non-linear and virtual location-based entertainment, per the techniques of this disclosure.

- The arena space is dynamically split into different regions, or zones.
- All games connect to an arena pipeline server, which dynamically allocates regions to teams.
- Allocated regions need not be of the same size, shape, or form factor. Rather, regions are allocated based on the requirements of the particular virtual environment. For example, a pirate-boat virtual environment can be allocated a long, narrow, physical region (e.g., that matches the shape of the boat), while a spaceship virtual environment can be allocated a squarish physical region.
- The venue operator identifies and maps regions of the physical venue that are free of obstructions and safe to move. For example, the venue operator can exclude columns and escalators from regions where users can move.
- Based on the map created by the venue operator, for each user, a safe area is defined and mapped within a virtual room (zone) such that there are no physical obstructions that the user might bump into while experiencing VR.
- As players move from zone to zone, the user’s safe area is updated to limit or redefine the safe area accordingly.
If, despite the demarcation of a safe area, a user insists on exiting their virtual environment, e.g., by going through a virtual wall, then the virtual environment for that user is deactivated, e.g., the user starts experiencing real, physical space, including visualization of the multiple concurrent teams occupying the physical venue. Deactivation of the virtual environment can be done by camera pass-through, e.g., the camera on the user’s head-mounted device can send a feed of real, physical space to the user’s visual field. Upon such a violation of the virtual environment, corrective action can take place, e.g., the venue operator can instruct the errant user to get back into the virtual space or exit the physical venue. For safety reasons, players in the proximity of the errant user can also have their virtual environments temporarily disabled.

- When a group leaves a zone, another group can enter the zone.
- A group is unconstrained by a required minimum number of team members. For example, a single individual can constitute a team, without waiting for a minimum of (say four) individuals to form a team. The absence of a required minimum number of team-members adds to the operational flexibility of the venue.
- Games can be designed to move players into adjacent open zones when timers expire. This is most effective for games that have adaptive, or dynamically-designed, content that expands and contracts to the available space, with a choice of multiple exits that become accessible when it is time to move into the next zone.
- Games collaborate with the arena server to negotiate access to zones based on content, timers, and other factors. Player decisions can be one of these factors, e.g., players choose one of three exit doors to open based on in-game events.
• When players move to the exit zone and it is time to end the session, cameras on players’ head-mounted devices are enabled such that mixed reality is passed through.

• The pipeline server can route players through the same zones multiple times to extend the LBE experience.

• Games can be designed to accommodate groups moving at different speeds, routing around groups that are stalled for any reason. Zone encounters are designed to accommodate a certain amount of variable time in the zone by extending the zone experience until the required zone is available. This can be done by suitably introducing elements that fit the theme, e.g., by continuing to spawn (virtual) opponents.

• Zones are not necessarily of fixed sizes; as players move through the content, portions of the arena that are reserved for a zone can vary based on the content requirements. Some of the space used by a long narrow hall for one experience might, for another experience, be part of a square room for another experience. The arena server can allocate portions of the arena to zones as needed for each concurrent experience.

The combination of the above features enables different games or durations of experiences to coexist in the same arena. Groups that enjoy their VR games can traverse the physical venue in circles (or other overlapping paths) for very long times, for as long as they are inclined to do so. Different themed entry points can funnel customers into a large, shared space. Some zones can have special equipment installed such as wind and heat generators, floor vibration, or other devices that stimulate the senses. The arena pipeline server directs groups to appropriate zones based on the different content requirements of the corresponding gameplay servers.

Because of the space partitioning and the rogue-like (e.g., dynamic, pseudo-random, on-the-fly game generation, evolution, and outcome) room connections, the physical venue does not
need to be a specific size or even a convex shape. The arena pipeline server can support the irregular layouts common in retail stores, with all the physical constraints that come with it, such as supporting columns and escalators in the middle of the space.

For example, a small-to-midsize repurposed retail space for an LBE might be a 10,000 square foot space, nearly 1000 square meters, or slightly larger than a 30m by 30m rectangle. Such a space can be subdivided into 6x6 meter square zones to produce a 5x5 grid of cells. Further content flexibility can be provided by partitioning the arena into a grid using a finer resolution, e.g., to the extent of centimeters. With appropriate content planning, such a large (e.g., 10,000 square foot or larger) space can accommodate content that incorporates redirected walking techniques at a scale not currently possible. The high efficiency afforded by the techniques described herein can enable LBE-venues to support many more customers per hour than currently possible.

**CONCLUSION**

This disclosure describes techniques to dynamically partition a physical venue into regions, where regions are locked by players as they move around based on game-content. Regions support branching, e.g., non-linear content such as multiple exits per region (virtual room). The techniques enable LBE experiences with arbitrary duration and player agency. The usage of large physical spaces is optimized to support a large number of concurrent groups that can go through different VR experiences in a safe and systematic manner.

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