Bringing the Bible to Life with Ultra Wideband

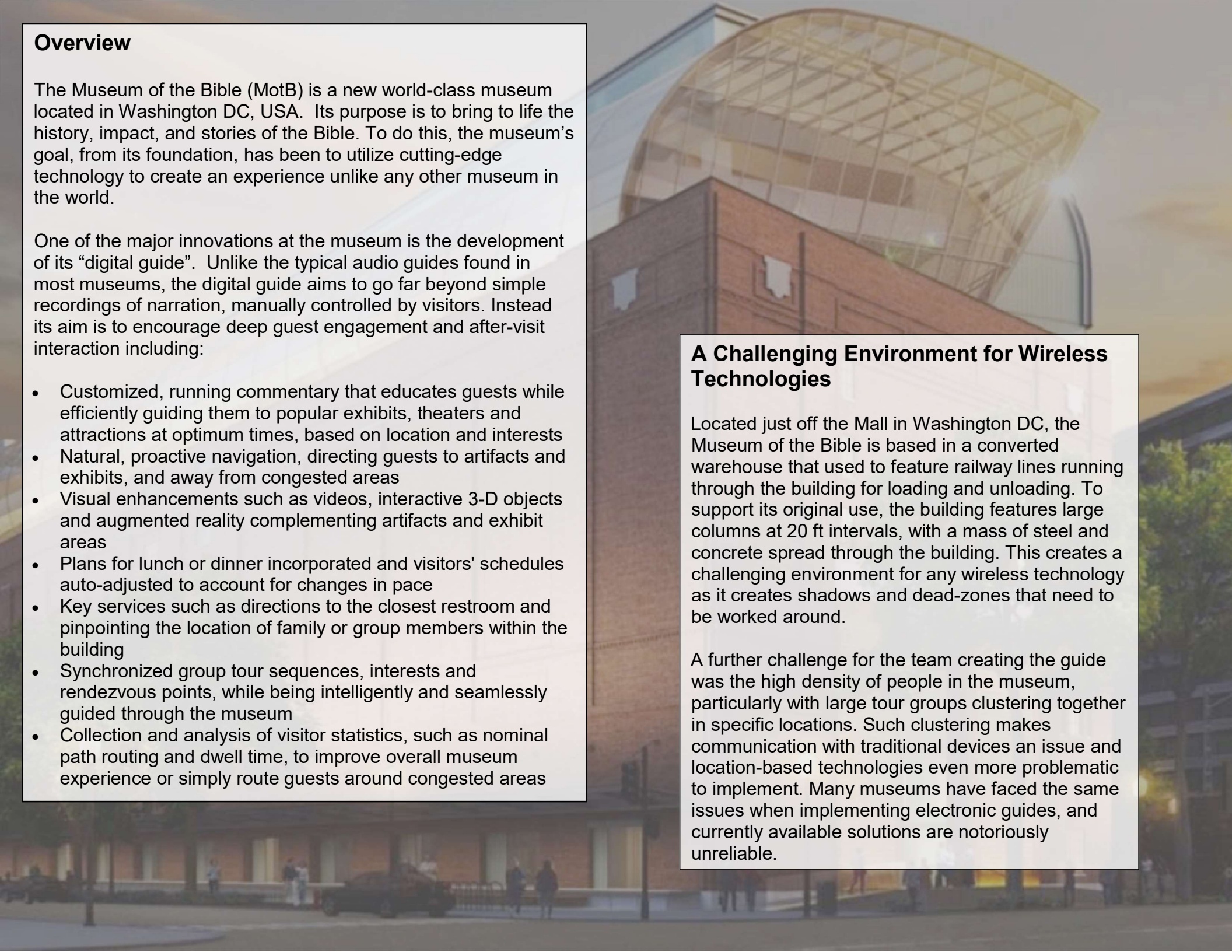
"Utilizing the Decawave DW1000 UWB chip, the location system used in the museum can measure distance so precisely and inexpensively that we believe this technology will be as transformative to indoor navigation as GPS has been for large-scale navigation."

Museum of the Bible

Decawave

museum of the Bible

CIHOLAS



Overview

The Museum of the Bible (MotB) is a new world-class museum located in Washington DC, USA. Its purpose is to bring to life the history, impact, and stories of the Bible. To do this, the museum's goal, from its foundation, has been to utilize cutting-edge technology to create an experience unlike any other museum in the world.

One of the major innovations at the museum is the development of its "digital guide". Unlike the typical audio guides found in most museums, the digital guide aims to go far beyond simple recordings of narration, manually controlled by visitors. Instead its aim is to encourage deep guest engagement and after-visit interaction including:

- Customized, running commentary that educates guests while efficiently guiding them to popular exhibits, theaters and attractions at optimum times, based on location and interests
- Natural, proactive navigation, directing guests to artifacts and exhibits, and away from congested areas
- Visual enhancements such as videos, interactive 3-D objects and augmented reality complementing artifacts and exhibit areas
- Plans for lunch or dinner incorporated and visitors' schedules auto-adjusted to account for changes in pace
- Key services such as directions to the closest restroom and pinpointing the location of family or group members within the building
- Synchronized group tour sequences, interests and rendezvous points, while being intelligently and seamlessly guided through the museum
- Collection and analysis of visitor statistics, such as nominal path routing and dwell time, to improve overall museum experience or simply route guests around congested areas

A Challenging Environment for Wireless Technologies

Located just off the Mall in Washington DC, the Museum of the Bible is based in a converted warehouse that used to feature railway lines running through the building for loading and unloading. To support its original use, the building features large columns at 20 ft intervals, with a mass of steel and concrete spread through the building. This creates a challenging environment for any wireless technology as it creates shadows and dead-zones that need to be worked around.

A further challenge for the team creating the guide was the high density of people in the museum, particularly with large tour groups clustering together in specific locations. Such clustering makes communication with traditional devices an issue and location-based technologies even more problematic to implement. Many museums have faced the same issues when implementing electronic guides, and currently available solutions are notoriously unreliable.

Choosing the Right Technology

The museum considered the full range of competing location technologies, from GPS to Bluetooth to Wi-Fi and dismissed them all due to their inability to meet the fundamental need of the project - providing the consistent, accurate location needed for the guide to be effective.

The museum turned to Ciholas and their comprehensive UWB-based solution, powered by Decawave technology. A key deciding factor was that UWB technology had already proven to be both accurate and reliable in challenging environments like the MotB building. Ciholas' successful UWB installations included harsh industrial environments, as well as use in a broad mix of industries, such as sports and entertainment.

System Foundation

To meet the challenges caused by the construction and layout of the museum, nearly 600 of Ciholas' DWETH UWB anchors were installed to cover 40,000 square meters of floor space over 7 floors. Almost all publicly accessible areas in the museum are covered by the UWB network. For ease of installation the anchors are connected and powered via standard wired Ethernet infrastructure and are mounted unobtrusively with various mounting schemes and colors.

The anchors are networked to servers in the basement of the museum that run the Ciholas Ultra Wideband (CUWB) system. The CUWB servers manage the anchor network, perform anchor synchronization, perform location computations, log system data and performance, and manage the digital guide update process.

Ciholas constructed the guide from a commercially available phone, adding custom electronics to interface with the UWB system and enable key guide features. The heart of the guide electronics is an UWB system featuring Decawave's DW1000 transceiver using an integral UWB antenna. The system also incorporates a microprocessor to handle UWB communications and computations.

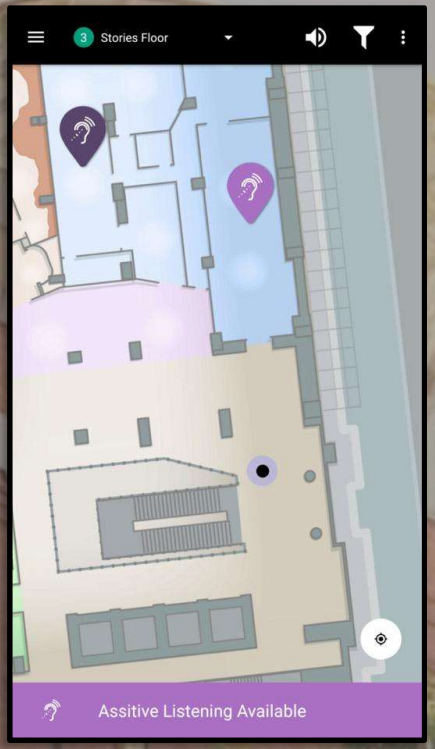
Digital guide electronics are not limited to UWB communications and location. Ciholas added an FM radio receiver for ADA audio delivery, which can be tuned to the proper channel based on the UWB location. Additionally, the system features wireless charging, 9-axis motion sensing, barometric pressure sensing, and bulk storage for system over-the-air updates. The phone and added electronics are housed in a custom-made injection molded plastic enclosure with integrated handles, grips, and strap mounts.

Location, Location, Location

To overcome the challenges introduced by the high-density of digital guides, Ciholas tapped into the flexibility of Decawave's UWB chip. Typical UWB location systems use 'track mode' to track objects moving in an area with the location being computed and used on central servers. This is very effective for applications where the position data is not needed locally, such as pallets in a warehouse.

In the case of the digital guide, the device needs its own location for use in the guide application. It is possible to use track mode by having the servers send the location back to the guide; however, it is less than ideal as wireless communications introduce latency, network congestion, and decrease reliability. Transmitting position data back to the guides would also limit the number of trackable objects in any one area.

The digital guide implements "navigation mode" location to solve the congestion issue. Navigation mode operates similar to GPS with coordinated UWB signals transmitted from the anchors. The anchor signals are used by the guide to compute its location 10 times per second - good enough for even the swiftest museum visitor! The high update rate contributes to improved precision enabling smoothing and filtering of the data. The enabling feature of navigation mode is that any number of digital guides can simultaneously receive the anchor packets. There is no limit to the number of guides that can be located in any given area.



Location data is calculated at the museum in the server using track-mode and the digital guide using navigation mode. The guide application uses the high repeat rate location data directly from navigation mode to deliver location-based content, change ADA FM channels, and navigate visitors through the museum. The server uses the location data computed by track mode for whole museum analytics. Track mode data is limited to location calculation every 1-2 seconds per guide. The low data rate is necessitated by the number of digital guides on the system and is more than sufficient for tracking guests to analyze congestion or help families meet up.

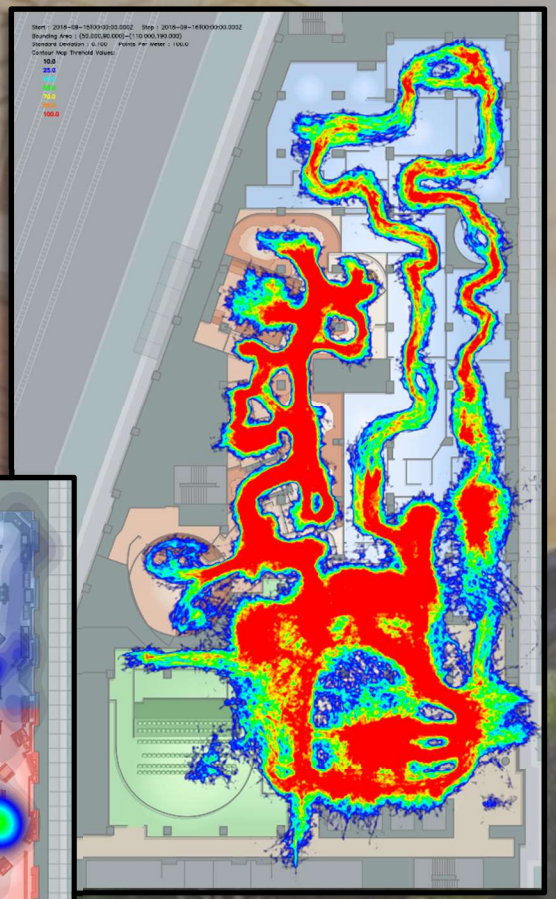
A key part of the system is the algorithm, or the "location engine," that computes the location from the UWB data. The location engine used in navigation mode in the digital guide and track mode in the servers is a proprietary algorithm developed by Ciholas called Vectorization and Mapping (VM). VM is particularly good in real world situations, such as the museum, where the UWB signal may be partially or wholly obstructed. The VM algorithm can detect and mitigate when signal occlusions occur thus limiting the effect of bad data on the output and delivering best-in-class location performance.

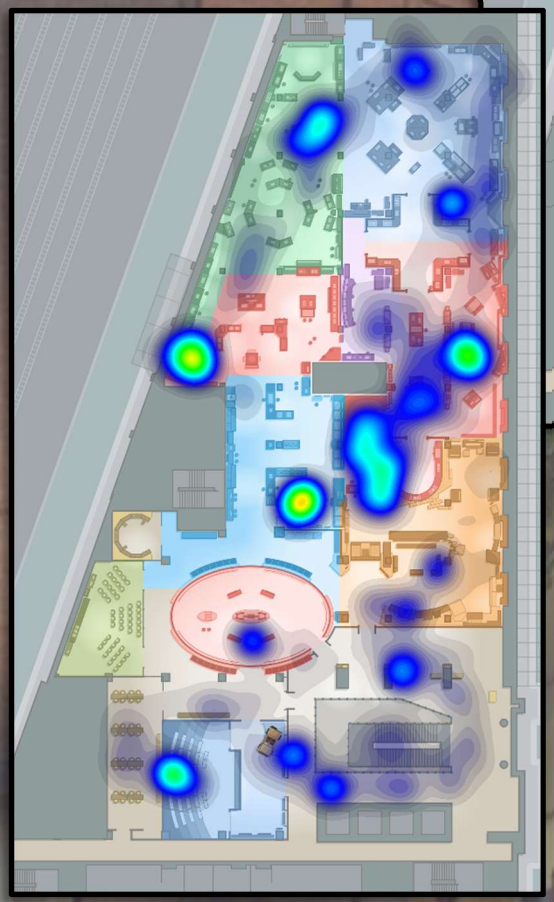
Improved Experience

In today's technology driven world, it is almost expected for organizations like the museum to capture data and apply big data analytics to realize value. The Ciholas CUWB system provides the Museum of the Bible with extremely valuable information regarding visitor experience.

To realize this potential, the location data collected from the digital guides is streamed to a time-based database for post analysis. At the most basic level, the data can be analyzed over a small period providing live heat maps that can be used to identify congestion and improve guest experience by managing traffic flow. Larger periods of data are also collected and analyzed, providing information on path planning and allowing the digital guide to improve suggested routes for visitors.

The location data analytics aren't limited to path planning and congestion. The time-based data also allows the museum to evaluate dwell time to identify visitor interests and determine popularity of exhibits or artifacts. Paired with the path data, the visitor dwell time data can also be used to provide hints to curators regarding signage and advertising for areas that aren't performing as expected.





Looking to the Future

The digital guide system at the Museum of the Bible delivers a unique and groundbreaking application for UWB in a demanding environment, and the guides are already delighting visitors. The detailed data delivered by the system provides opportunities for further development over time:

- The data can also enable new guide capabilities. Knowing how much time a visitor has and what their interests are, the guide could create a personal tour for them. Even better, with real-time congestion data, the guide could reorganize the tour as it happens to create the best possible experience. All of this can be done without any personally identifiable data, removing any privacy concerns.
- The guide and location data could be used to keep families together. Providing children with a different experience than adults while keeping them in the same vicinity as one another. The device could also create independent tours for family members, bringing them together for activities like lunch, or a theater experience, at a set time.

See you at the museum!

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