THE WIRELESS POSITIONING SYSTEM PORTFOLIO

A Patent Portfolio Acquisition Opportunity

Diani Systems, Inc.

Wireless Positioning Systems

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Executive Summary

IPinvestments Group has been retained by Diani Systems, Inc. to broker the sale of pioneering and foundational patented technologies (the "Portfolio") related to high accuracy (sub one meter) time-of-flight based positioning systems. The Portfolio essentially enables positioning of a mobile device in an indoor setting with an indoor network such as WiFi. These places may include a mall, hospital, retail store, or shopping center. Generally, the Portfolio covers two loosely related but synergistic technologies: (1) use of frequency-hopped IEEE 802.11 WiFi, or similar, transmissions to span a broad range of frequencies, yielding nanosecond time-of-arrival estimation accuracy in indoor multipath-rich environments - a technique referred to herein as Ultrawideband WiFi or UW-WiFi,signaling, and (2) systems and methods for network broadcast time-of-flight-based positioning that do not require tight synchronization among network broadcast terminals, herein referred to as Asynchronous Broadcast Differential Time Difference of Arrival (AB-DTDOA) signaling.

The Portfolio's innovative UW-WiFi technology is a signaling concept in which a transmitter device sends two or more narrowband signals sequentially in time at different frequencies to a receiver device to span a desired bandwidth. The receiver digitizes and stores the sequence of incoming transmissions, then uses the received sequence and the known or estimated timing and carrier phase differences among the transmitted signals to estimate their time and/or angle of arrival. This allows today's wireless standards such as IEEE 802.11/WiFi to use very wide bandwidth signals (in excess of 500 MHz for WiFi) for ranging. Hence, ultra-wide-bandwidth (UWB)-like positioning accuracies of 3 ft. or less, a factor of ten times more accurate than today's state-of-the-art indoor positioning systems is achieved by WiFi devices that ship in annual quantities of over one billion units at virtually no extra cost. In summary, UW-WiFi makes WiFi signals behave like UWB signals for the purposes of super-accurate ranging and location.

The Portfolio's other innovative technology, AB-DTDOA, allows for the deployment of an indoor GPS-like system without the need for transmitters to be tightly synchronized. For sub-meter location accuracy, the network terminals need to be synchronized to within a fraction of a nanosecond, which is a very difficult and potentially costly requirement to meet. The AB-DTDOA approach solves this difficulty by re-defining the broadcast scheme in such a way as to remove the need for synchronization altogether. AB-DTDOA can be used to greatly simplify the deployment of UW-WiFi in broadcast-based indoor positioning systems (e.g., an indoor GPS using UW-WiFi-capable WiFi APs as the "satellites") by removing the need for synchronization among the APs. More generally, it can be used to help any time-of-flight based location system, even GPS itself.

The UW-WiFi technology was partially funded by grants from the National Science Foundation (NSF). The grants were awarded in two phases: $150K in phase I and $500K in phase II for a

total of $650K of grants from the NSF. These grants were used to develop and test UW-WiFi in real-world environments using radio-frequency (RF) test equipment. During this testing it was shown that the UW-WiFi technology performed as well as it was predicted; the Diani engineers were able to demonstrate better than 3 foot location accuracy with 90% confidence in 3 representative indoor environments using 480 MHz signaling bandwidth. The setup and results of this testing can be provided upon request.

At this time, the Portfolio is being offered to select companies, as well as patent acquisition and financing organizations, who participate in the relevant markets and related industries. The table below summarizes the Portfolio.

PATENT NO.	TITLE	SERIAL NO.	FILING DATE	ISSUE DATE
8,179,816	System and method for high resolution indoor positioning using a narrowband RF transceiver	13/286,649	11/01/11	05/15/12
8,265,011	High resolution wireless indoor positioning system for legacy standards-based narrowband mobile radios	13/355,557	01/22/12	09/11/12
8,687,560	Unsynchronized time-of-flight-based wireless positioning system using network broadcasts	13/968,837	08/16/13	04/01/14
13/602,451	High resolution wireless indoor positioning system for legacy standards-based narrowband mobile radios	13/602,451	08/16/13	Notice of Allowance 12/16/14
13/891,123	Indoor positioning system for standards-based narrowband mobile radios using spectrally overlapping transmissions	13/891,123	05/09/13	TBD
EP2635917A1	System and method for high resolution indoor positioning using a narrowband RF transceiver	WO2012061479	05/30/13	TBD

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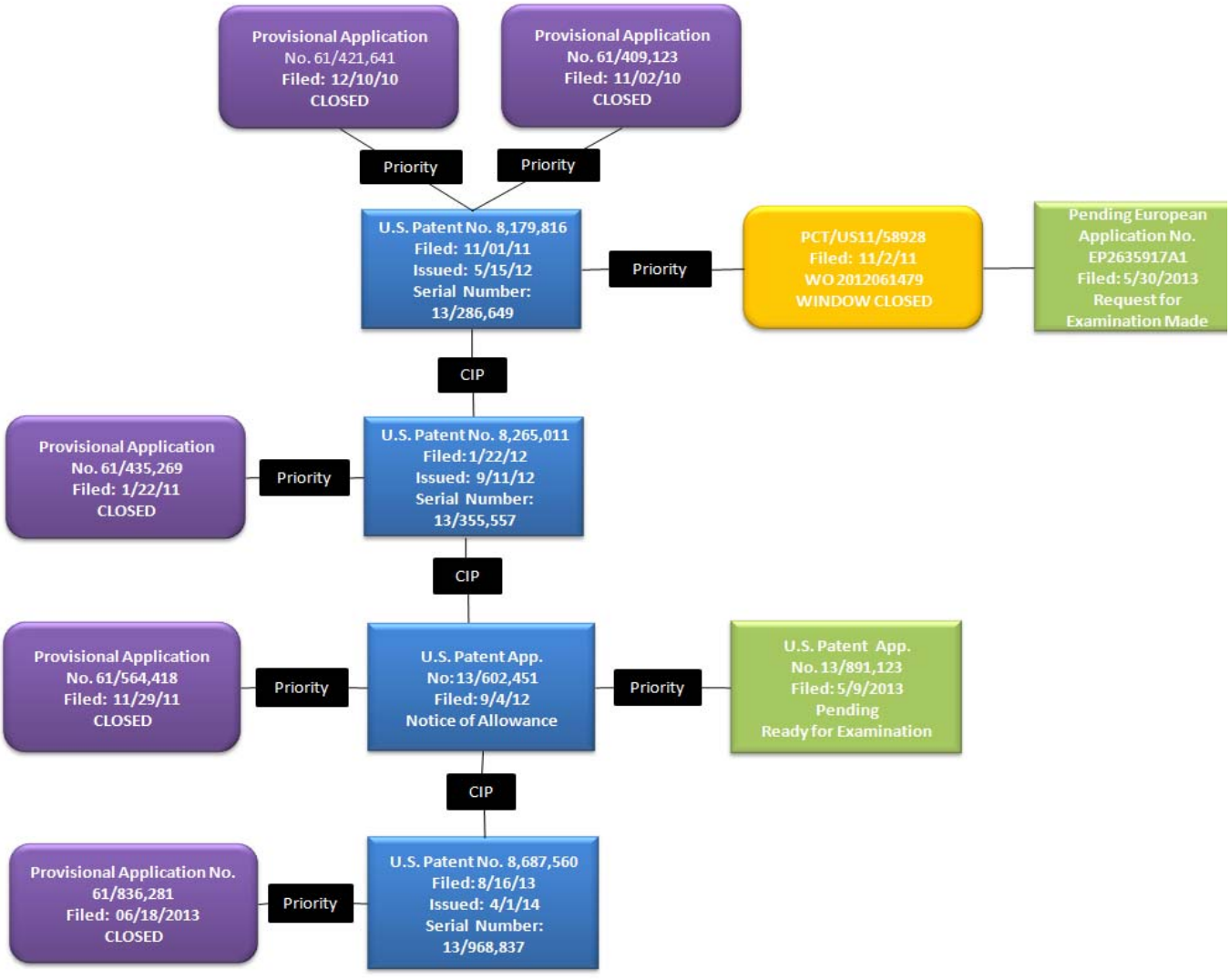
The Portfolio consists of issued U.S. Patent Nos. 8,179,816 (the '816 Patent), 8,265,011 (the '011 Patent), 8,687,560 (the '560 patent), and allowed U.S. Application No. 13/602,451 (the '451 application) and claims priority back to 2010. There are pending U.S. and European applications related to the issued patents. The family relationships of the assets in the portfolio are illustrated in the below flow chart.



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Market and the Patented Technology

WiFi coverage in indoor environments is becoming ubiquitous, thereby driving the market for indoor positioning systems that utilize existing networks such as WiFi. Other forces driving this market is the increasing customer intimacy with mobile devices, unreliable GPS technologies in indoor locations, and a need for improved public safety in indoor environments. Also, lean automation, lean robotics, and increasing building size gives rise to new business scenarios that require indoor positioning systems. Businesses also demand systems that offer quick customer adoption which offers an advantage to systems that utilize current indoor networks.

Markets and Markets estimated the global indoor location market to be $935 million in 2014 and expects it to grow to $4.4 billion by 2019. North America is expected to be the biggest market in terms of revenue contribution, followed by Asia Pacific regions. Major players in this market are **Apple, BroadCom, Cisco, Ericsson, Google, Nokia, Microsoft, Motorola, Qualcomm, and STMicroelectronics**.[1]

One of the biggest demands for the Portfolio comes from mobile retailers such as **Target** or **Best Buy** that want to offer location-based services for smartphones with aisle level accuracy, healthcare providers that want location of medical equipment and staff with room level accuracy, financials who want location based WiFi security, and manufacturing who want location of tools, equipment, and workers within station level accuracy. Other opportunities include location of friends and family members, classroom location for colleges, route guidance for the blind or wireless robots.

Indoor networks such as WiFi networks are often used to obtain positioning information. However, performance usually becomes an issue. The basic concept of WiFi positioning is to determine distances by measuring travel times, similar to GPS. However, some major differences between the technologies need to be addressed. For example, GPS satellites are synchronized using atomic clocks as opposed to WiFi, whose Access Points (APs) are not usually synchronized at all. Moreover, while GPS systems are typically time-of-flight (ToF) based systems, WiFi environments often exhibit significant multipath – signal reflections off of walls, ceilings, etc. that affect the arrival time of the signals, thereby making it difficult to determine the time-of-flight arrival times of the shortest distance path.

The Portfolio addresses these issues by offering two loosely related but synergistic technologies: (1) UW-WiFi (Ultrawideband WiFi) which uses frequency-hopped IEEE 802.11 WiFi, or similar, transmissions to span a broad range of frequencies yielding nanosecond time-of-arrival estimation accuracy in indoor multipath-rich environments, and (2) AB-DTDOA (Asynchronous

[1] http://www.marketsandmarkets.com/PressReleases/indoor-location.asp

Broadcast Differential Time Difference of Arrival) which describes systems and methods for network broadcast time-of-flight positioning that do not require tight synchronization among network broadcast terminals.

The Portfolio's UW-WiFi and AB-DTDOA technologies encompass a mobile client device such as a mobile phone or laptop, a plurality of sensor emitting (SE) devices, and a server. The sensor devices, typically the size of a WiFi access point, are placed at various known positions in an indoor environment. The server controls the mobile client and sensor emitting devices during the ToF measurements. The SE's can be configured as sensors which only receive ToF signals from the client device, other emitters which only transmit to the client device, or both. When configured as emitters, each SE periodically broadcasts location beacon signals allowing listening client devices to self locate by measuring the ToF of the beacon signals received from multiple SE's. This is similar to how GPS is used today, with satellites being the emitters for GPS. When configured as sensors, each SE measures the ToF of one or more transmissions received from the client to estimate its position.

All SE's in a network may need to be time-synchronized to a common time base. In emitter mode, this allows the SEs to transmit their location beacons at exactly the same time using multiplexing Time/Frequency Offset Wideband signaling. After receiving a set of beacon transmissions from SEs at known positions, a client can compute ToFs of these signals and estimate its position.

In sensor mode, the SEs monitor incoming transmissions from the client device, estimate their ToFs, and pass the ToF estimates to the server, which estimates the client position.

The AB-DTDOA technology of the Portfolio encompasses wireless positioning systems and methods that do not require synchronization among the network nodes, and does not require transmission from the mobile devices. Advantages to this approach are simplicity in implementation, prolonged battery life of the mobile device, and less bandwidth usage.

PATENTED TECHNOLOGY HIGHLIGHTS

There are a myriad of features and techniques disclosed in the Portfolio that enable interactive broadcasting, but the ones below, in particular, demonstrate the pioneering status of the patented technology:

UW-WIFI

- An indoor-positioning system and method through WiFi that supports but does not require synchronization of emitting devices.
- No hardware changes required. The UW-WiFi can be implemented using a firmware change to off-the-shelf WiFi chipsets that exist today.
- The UW-WiFi can achieve 3 feet accuracy with 90% confidence in indoor environments.
- UW-WiFi makes WiFi behave like UWB by providing up to 1 GHz of bandwidth for high resolution location without having to increase the WiFi signal strength or change any other regulatory restriction.
- Method for high resolution channel sounding that can be used to combat multipath in indoor wireless Time-of-Flight (TOF) based positioning systems. Using UW-WiFi signaling, a transmitter device sends a sequence of narrowband packets to a receiver device at different times and frequencies in order to span a desired bandwidth, where it is assumed that the time, frequency and carrier phase differences among the signal transmissions are known to the receiver. The receiver listens to the transmissions at the known times and frequency while digitizing and storing them for post-processing, uses the stored received signals and the known time, frequency and carrier phase differences to obtain a high-resolution time-of-arrival estimate of the received signals.
- Positioning system and method designed specifically to be used with pre-existing wireless standards such as IEEE 802.11, WiFi, Bluetooth, GSM, GPRS, EDGE, CDMA, 3G, WiMax, and others.
- Positioning system and method requiring only the network side to have knowledge of UW-WiFi signaling, thereby allowing any wireless device to be located.

AB-DTDOA

- Signaling approach that allows one or more mobile wireless devices to self-locate by monitoring periodic broadcasts from wireless network nodes that does not (1) require synchronization among network nodes and does not (2) require transmission from the mobile devices (prolongs battery life and saves bandwidth)

- Similar to GPS in that it allows the mobile device to self-locate by measuring the ToF of signals broadcast by the network without requiring the tight time synchronization that GPS systems require.

- Can be combined with WiFi or any ToF systems to yield a very powerful indoor GPS-like positioning solution.

- Less than a 1% throughput overhead required for access point (AP) broadcasts, regardless of how many clients.

- Clients do not transmit, a feature that adds security.

- Implementation by software changes to both the network and mobile sides of the link.

REPRESENTATIVE CLAIMS:

'816 PATENT

1. A system for calculating the time of arrival of a wireless signal through a wireless channel, comprising:
   a receiver device that
   receives a sequence of two or more data packets transmitted through a wireless channel, wherein the two or more data packets are a result of two or more transmissions that are made sequentially in time at different center frequencies in order to span a desired bandwidth and wherein each data packet of the two or more data packets includes a physical layer preamble and is transmitted at a single center frequency, and
   calculates a time of arrival of one or more data packets in the received sequence using each data packet of the received sequence and one or more of the time differences among the two or more transmissions, the different center frequencies, and any carrier phase differences among the two or more transmissions.

'011 PATENT

1. A system for calculating the time-of-arrival of a wireless signal through a wireless channel, comprising:
   a receiver device that
   receives two or more data packets transmitted through a wireless channel, wherein the two or more data packets are a result of two or more transmissions that are made sequentially in time at different center frequencies in order to span a desired bandwidth, wherein each data packet of the two or more data packets is transmitted at a single center frequency, and wherein the two or more received data packets represent narrowband signals that span the same desired bandwidth as a wideband signal,
   estimates time differences among the two or more transmissions and/or carrier phase differences among the two or more transmissions, and
   calculates a time-of-arrival of any one of the two or more data packets using each of the two or more received data packets and one or more of the estimated time differences, the different center frequencies, and the estimated carrier phase differences, wherein using each of the data packets of the two or more received data packets in the calculation allows the time of arrival to be calculated with the same accuracy as a wideband signal that spans the same bandwidth as the two or more received data packets.