Unambiguous Base Station Identifier Code in Widely Picocells area using Golay Complementary Sequence

Thamir R. Saeed[1] Ivan A. Hashim[1] Sameir A. Aziez[2] Qussay S. Tawfeeq[1] Wissam H. Ali[1]

Abstract

The wireless communication system has at least one picocell within macrocell. The use of picocell gives many advantages, saving a radiation power, increase the capacity and improve the dead zone. However, in a system where a large wide-area cell overlapped with many of picocells, many of the picocells will have to re-use the same Base Station Identifier Code (BSIC- small number of bits). Hence, when an MS roams from the wide-area cell into a target picocell, the reported BSIC may be ambiguous. The optimal operating point of the combination above was obtained by analysis of cell distribution. This paper presents a new algorithm to classify the user according to mobility narrow and widely, then use Golay code complementary sequences for widely mobility user and implement a tracker circuit to track the user for accurate handover decision. The accuracy is satisfied by using Golay code and by tracking the user. Furthermore, the implementation of Golay code creator, correlator and tracker circuit by using Xilinx-spartan-3A XC3S700AFPGA, with 50 MHz internal clock is supported for increasing the speed of operation and accuracy.

Key words: Wireless communication, Picocell, re-use distance, Golay sequences, FPGA-Spartan,

[1] *Department of Electrical Engineering, Univ. of Technology*
[2] *Department of Electromechanical Engineering, Univ. of Technology,*

1. Introduction

The wireless communication system has at least one picocell within a macrocell. A method of communicating in that system includes using a set of predefined cell codes for respectively identifying macrocells. At least, one predefined cell code is used for identifying all picocells within a macrocell to the macrocell. A picocell code distinct from the predefined cell codes is used for uniquely identifying a picocell to a mobile station with the macrocell. The mobile station can translate between the predefined cell code used by the macrocell to identify all picocells and the picocell code used to uniquely identify the picocell to the mobile station {1,2}. Even so, in a system where a large wide-area cell overlap with a large number of picocells, many of the picocells will have to re-use the same Base Station Identifier Code (BSIC- small number of bits). Hence, when an MS roams from the wide-area cell into a target picocell, the reported BSIC may be ambiguous {3}.

A picocell is a small cellular base station typically covering a small area (up to 200 m(nearly from 50-200 m)), such as in-building (offices, shopping malls, train stations, stock exchanges, etc.), or more recently in-aircraft. In cellular networks, picocells are typically used to extend and improved (fewer dead zones) coverage to indoor areas where outdoor signals do not reach well, or to add network capacity in areas with very dense phone usage, such as train stations. Picocells provide coverage and capacity in areas difficult or expensive to reach using the more traditional Macrocell approach. Multiple picocell 'heads' connect to each BSC: the BSC performs radio resource management and hand-over functions, and aggregate's data to be passed to the Mobile Switching Centre (MSC) and/or the Gateway GPRS Support Node (GGSN) {2,4}. In the existing technical literature, many related studies on picocell handover decisions have been reported.

The invention {5}, relates to handover in a cellular communication system. In addition, there is provided a cellular communication system, including the number of base-stations with unique cell scrambling codes and several access points. {1} was working on a cell code for identification between picocell and macrocell.

For reduction the interference and increase the system capacity, the division of the worked region to the picocell was presented by{6}. {7} also worked for the division of the worked area, but he looks from the perspective of the contextual of data. In the identification of information managing in a relay station /femto/picocell {2} was described a method. For using base-station location to assist mobile-device system acquisition a method and system were presented by {8}. {9}characterize the picocell network performance for moving user and various traffic model and present a waiting time expression.

2. Picocell Analysis

Communication networks system has three axes; each one had many factors; these are; Network cell, Filed of operation and the user. The filed is usually calculated implicitly of the cell design equipment's. Then, the important factors in cell side are;
Cell size, system properties (bandwidth, identification code, transmitted/ received power, and interference), and from the user side (number, mobility and bit rate). To dismantle the interdependence, for arranging and to find the optimal operating point of the network as distributed (spectrum and codes for many picocells) as in Figure (1)

The total bandwidth will be divided into three parts, uplink bandwidth, downlink bandwidth, and guard bandwidth. From these bandwidths can obtain the number of channels and users {10};

$$MU = NH - 1 \leq \sqrt{\frac{BW_{total}}{BW_{up} + BW_{dwon} + 2*BW_g}} \propto \frac{1}{user\ data\ rate} \quad (1)$$

Where;

$MU - mobile\ unit\ (user)$.
$NH - number\ of\ channel$.
$BW\ - bandwidth\ (total, uplink\ and\ downlink)\ Hz$
Minus one – for keep one channel for argent case.

Cell ID information is transmitted through a synchronization channel {2}. A mobile station, which stores a network identifier, selects a carrier frequency.

The mobile station receives, from a base station on a first carrier frequency, geographic coordinates of the base station and a base-station network identifier, and determines whether the base station network identifier matches the mobile station network identifier. If its matches, after that connected to one of the home frequencies. And if its not matches, later, geographic coordinates of the base station are used to identify a market area and most-preferred carrier frequency is selected from the identified market area.

The velocity of the user can be determined from the location of it or from the time received, signal in a traffic massage center {11}. Their locations are determining continually by GPS. To ensure continuously of service, user velocity must be limited, this limitation is related to the *Tx* power (*p*), where;

$$V_{lim}(P) = \frac{2\,P\,d_o}{\beta-1}\beta \qquad \textbf{(2)}$$

Where;

V – user velocity (V_{lim} – limitation of it) m/s.

β – path loss factor ≥ 1

d_o – distance with no loss (m).

Then, can determine the rate of handover, where;

$$rho = v\,\frac{Sp}{L} \qquad \textbf{(3)}$$

Where;

rho – rate of handover

v – call velocity

Sp – total byte which Tx/Rx through one picocell.

L – length of picocell $\geq 2d_o$

The spectrum distributed, may be anticlockwise or clockwise as in Figure (1){2,12}, and then reuse it in the other cells with same distribution, for maximum spectrum efficiency must use the distance ratio equal to two. The service of users means time and bit rate, which communicates through the network.

The statuses of the use are fixed or moving, there is no problem in the first status when made a calibration between the user number and the spectrum. However, the problem when the user is in motion, the continuity of the service related to the speed of user motion, the range of his mobility, the data which communicated and the cell size, will be related as;

$$t_b = \frac{S}{Sp} \frac{L}{V} \quad (4)$$

Where;

$t_b - service\ time$ (sec)

$S - total\ byte\ which\ Tx/Rx\ through\ service\ time$

Then from the above analysis, the optimal operating point as in table (1)

Table (1) optimal operating point of Picocell inside macrocell.

picocell area (m^2)	distance ratio	o/p power dbm	Total BW (GHz)	Data rate (Mb/sec)	Active user	Spectral efficiency (bps/Hz)	Base station density (no. of BS/ Km^2)	supper frame length (msec)	Max. user velocity (m/sec.)
31.625	2	+ 23	1 - 3	1 - 10	16	5.2	20	20	<200

3. Golay Code Complementary Sequences Formulation

Golay sequences have some properties that make it distinctive in the applications and results. However, for this distinction, the code sequences must be selected carefully and accurately. The property of Golay complementary sequences can be expressed mathematically, where a_i and b_i (i = 1,2, . . ., n) are the pair of binary complementary sequences of code length 2^n. The AACFs for the complementary sequences can be expressed as follows {13}:

$$c_j = \sum_{i=1}^{n-j} a_i \, a_{i+j} \tag{5}$$

and

$$d_j = \sum_{i=1}^{n-j} b_i \, b_{i+j} \tag{6}$$

The sum of the pair of AACFs can be expressed as;

$$\left.\begin{array}{ll} c_j + d_j = 0 \quad j \neq 0 & \text{for specific unique pair} \\ c_j + d_j \neq 0 \quad j \neq 0 & \text{for other} \end{array}\right\} \tag{7}$$

and

$$c_0 + d_0 = 2n \tag{8}$$

4. Proposed Algorithm

To overcome the ambiguity problem of MS ID code, a new algorithm for was proposed. This algorithm is based on a modern classify MS user according to its mobility (widely and narrow mobility). Then according to this classification can give the normal ID code to the user, which moves with usual mobility (where it roams within code and spectrum distribution). While the user who moves in wide area and roams up to re-use the code and spectrum area, this user can give it a Golay code as ID code. While, the user who may be moved in all regions can give it the two codes above, and by use, the tracker circuit to decide which code must be used at a certain time. The algorithm deals, give the Golay code (A) to the roaming user and save its complementary (B) in the traffic massage center. Then, the user transmits the code (A) all time with its identifying a massage and when need can determine the unique user by Golay code properties equations(3,4Golay). Figure(2) represents the block diagram of create and auto-correlation of Golay complementary code sequence with its inside details. After that, when the user transmits its (A) code, the determination process will be determined which code related to that user who transmits (A) from stored (B's) as in equations (5-8), by adding the auto-correlation of (A) to the auto-correlation of (B). Afterwards, the result will be 2N as main lobe and zero as a side-lobe. While, the output of (A) with other (B) gives 2N as main lobe and non-zero as a side-lobe, therefore, the checking will be the side-lobe; Figure(3) represents these output details. In addition and, before the user enters the handover region(or handover request), the BS must track the enclose of user to cell by the comparison process with a certain level which represents the edge of re-use distance. The tracker circuits block diagram as in Figure (4-a) and Figure (4-b) represent FPGA schematic diagram of the tracker circuit using Xilinx-spartan-3A XC3S700AFPGA and Figure(4-c) represent its output. Where, the changing from enclose to be constant to go-away according to the location of the user with respect to the re-use cell distance is clear and on time. Where, the response of a tracker circuit with respect to the user moving behavior and the time-period details are shown in Table(2).

Table(2)

P	PRUS	-PRUS	RoT
$0-t_0$	03	00	User enclose =1
t_0-t_1	02	03	User goaway =1
t_1-t_2	09	02	User enclose =1
t_2-t_3	05-07	09	User goaway =1
t_3-t_4	07-09	05-07	User enclose =1
t_4-t_5	09	09	User cnstant =1
t_5-t_6	04	09	User goaway =1
t_6-	06-08	04	User enclose =1

P-period PRUS-present received user signal
-PRUS –Past received user signal RoT- response of tracker

The operation of the proposed algorithm will pass through many steps, as follows: The first one create the Golay complementary code sequence (A and B) as in stage (1) Figure(2).

The second steps use the Golay code as ID code for user who roam widely or in other at a needed time as in stage 2. When the user roaming in widely, the tracker will be started to track the user, when the user encloses to the reuse distance, the Golay code will be transmitted as ID code for that user. The indication of needed a Golay code will depend on the comparison with a certain threshold (re-use distance), where{14};

$$D = R\sqrt{3M} \qquad (9)$$

User distance ≥ D use Golay code as ID
User distance < D use normal ID

Where;

$D - reuse\ distance.$
$R - radius\ of\ hexagon\ cell.$

$M - number\ of\ cell\ which\ the\ spectrum\ and\ code\ distributed\ to\ it.$

The output of the tracker as shown in Figure(4-c) and the accuracy of determine the status of user distance is clear and in time as in period indication.

Afterwards, the third step when the user's distance crosses the reuse distance the received massage from the widely roaming will be checked according to the Golay code as in stage three of Figure(2). Auto-correlation will be made to the received A code and auto-correlation of the stored B's complementary, after that by applying the equation (7-8). Then, the indication of the result will be;

if $main\ lobe = 2N$ and $sidelobe = zero$ *for required user elseif* $main\ lobe = 2N$ and $sidelobe = non-zero$

The simulation output of the correlator as in Figure (3) and the real time output as in Figure(5) which represents the output result of the implementation circuit as in Figure(6)

5. Conclusion and Future Work

From the above work and analysis, there are some important points can be viewed; these are; First, the optimal point of operation represents the good point but not the beast one, because the effect of the operation field was reduced by β factor for simplicity. Therefore, to make its the best must make more analysis of the field of operation. Secondly, the usage of Golay code was given an assistant to overcome the ambiguous problem. The usage of Golay was adding a complexity to the network, but we reduce this complexity by use the checking (tracking) circuit for using the Golay at a needed time. The third points the implementation by using Xilinx-spartan-3A XC3S700AFPGA given an advance and flexibility to the network. The fourth points can use this network to serve the Oil Company or military which work in widely field space.

For the future work, I suggested the analysis of the number of users and the region which can re-use the Golay code in it. Furthermore, the service time for them, and the effecting of the capacity and on the service time of the holly network.

References

1. Holger C., Hamid R. K., Lester T. W. H., Louis G. S., "Establishing Cell Codes for Picocells Within A Macrocell", USP, Patent No. US 7,835,740 B2, 16 Nov. 2010.
2. Seung H. H., Yeong H. K., Jin S. K., Dong C. K., Sung H. M., Seok N., Hyun W. L., "Method for Managing identification Information of Heterogeneous Cells",USP, Patent No. US 2011/0195720 A1, 11 Aug. 2011.
3. Motorola, "GSM pico cell", prior ArtDataBase, 2005.
4. Tropos Network, "Picocell Maesh: Bringing low-cost coverage, capacity and symmetry to mobile WIMAX", Tropos Network, March 2007.
5. Howad J. T., Gerard T. F., Subramanian S. Lyer, Luis L., "Handover in A Cellular Communication System", USP, Patent No. Us 2008/0101301 A1, 1 May 2008.
6. Yifan L., Reinaldo V., Gerard F., Dmitry C. and Andrea G., "Interference Suppression in Wireless Cellular Network Through Picocell", IEEE Conference in signal, system and computers, Forty-First Asilmor, Pasific Grove, 4-7 Nov. 2007.
7. Shane D., Brendan J., Jonathan B., and Jason M., "Using Ambient Intelligence to Infer Availability and Meta-status in a Picocell Environment", IEEE seventh International Conference on Intelligent Environments, 2011.
8. Wei L., Abhinay T., "Using Base-Station Location to Assist Mobile-Device System Acquisition", USP, Patent No. US 2009/0325594 A1, 31 Dec. 2009.
9. Veeraruna K., Sreenath R., and Eitan A., "Spatial queueing for Analysis, Design and Dimensioning of Picocell Networks with Mobile Users", Elsevier 2011.
10. Hong B., Hagen W. and Adam W., " A Medium Access Control Protocol for Radio Over Fiber Wireless LAN Operating in the 60-GHz Band", IEEE 5th European Conference in Personal Mobile Communication, 22-25 Aprial 2003.
11. Bo-In L., "Transmission of Wireless Messages of Current Vehicle Location and Estimated Arrival Time to Requestors", USP, Patent No. US 2007/0197231 A1, 23 Aug. 2007.

12. Huiling Z., "On Frequency Reuse in Distributed Antenna System", IEEE Vehicular Technology Conference, Yakohama, 15-18 May 2011.
13. P.E. Pace and C.Y. Ng, "Costas CW frequency hopping radar waveform: peak sidelobe improvement using Golay complementary sequences", Electronic Letts. 21st January 2010 Vol. 46 No. 2.
14. Ankita K. P. and Radhika D. J., "Energy Conservation for Wireless Mobile Ad hoc Networks Using Hexagonal GAF Protocol", Recent Advances in Networking, VLSI and Signal Processing, 2010.

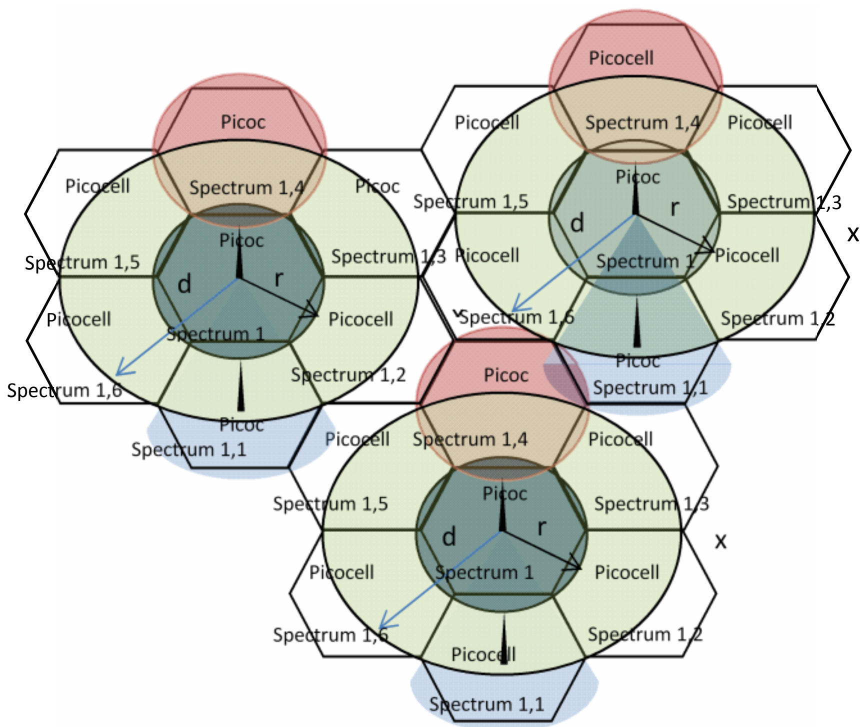
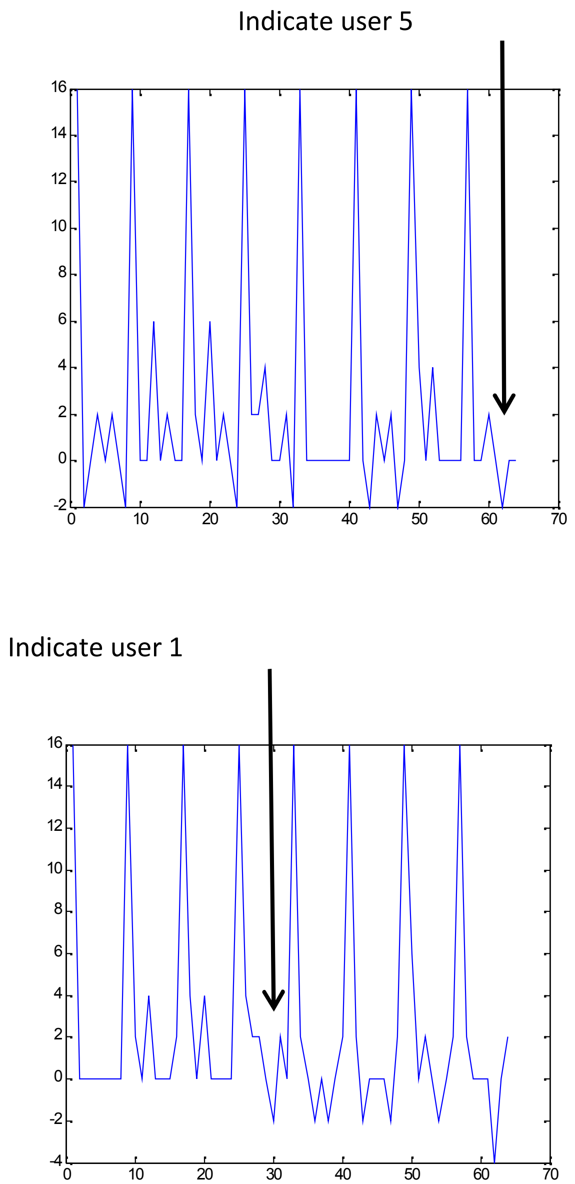
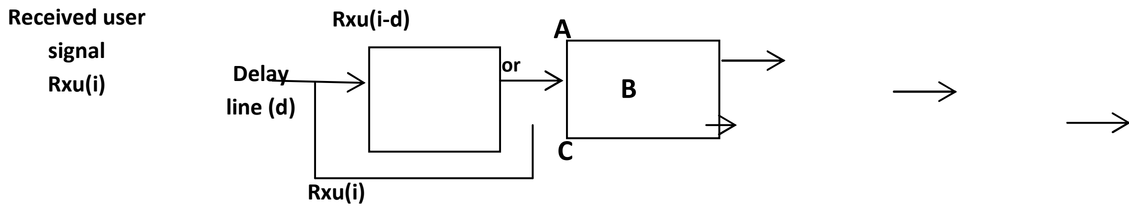


Figure (1) spectrum/code distribution



Figure(3). Output of equations (3,4) for complementary and not compatible complementary of Golay code sequences



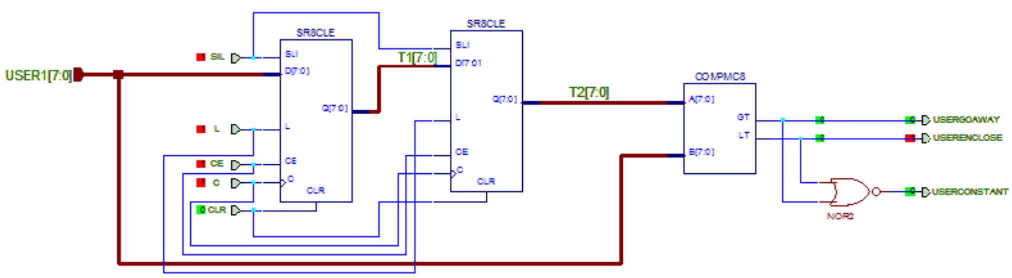
d – no. of delay line unit

A=1 if Rxu(i) > Rxu(i-d)   user enclosed to the near cell.

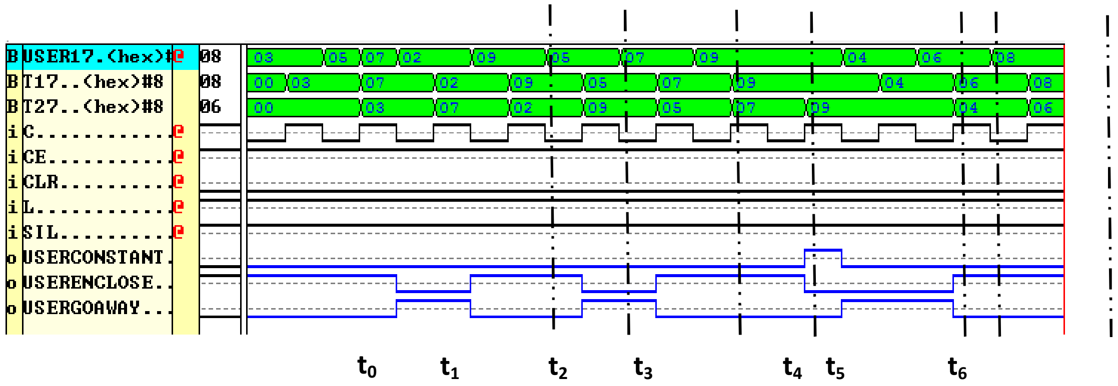
B=1 if Rxu(i) = Rxu(i-d)   user move around the near cell.

C=1 if Rxu(i) < Rxu(i-d)   user go away from the near cell.

Figure (4-a) tracker block diagram



Figure(4-b) implementation of user received signal tracker



USER17-Present received user signal

T27 - Past received user signal

Figure(4-c) tracker output with user received signal

t_0

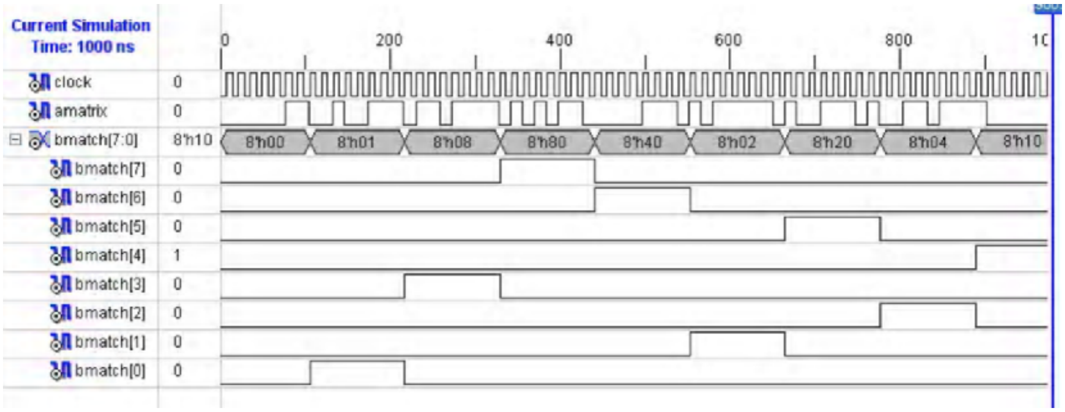


Figure (5). Output of the correlation process as built by FPGA

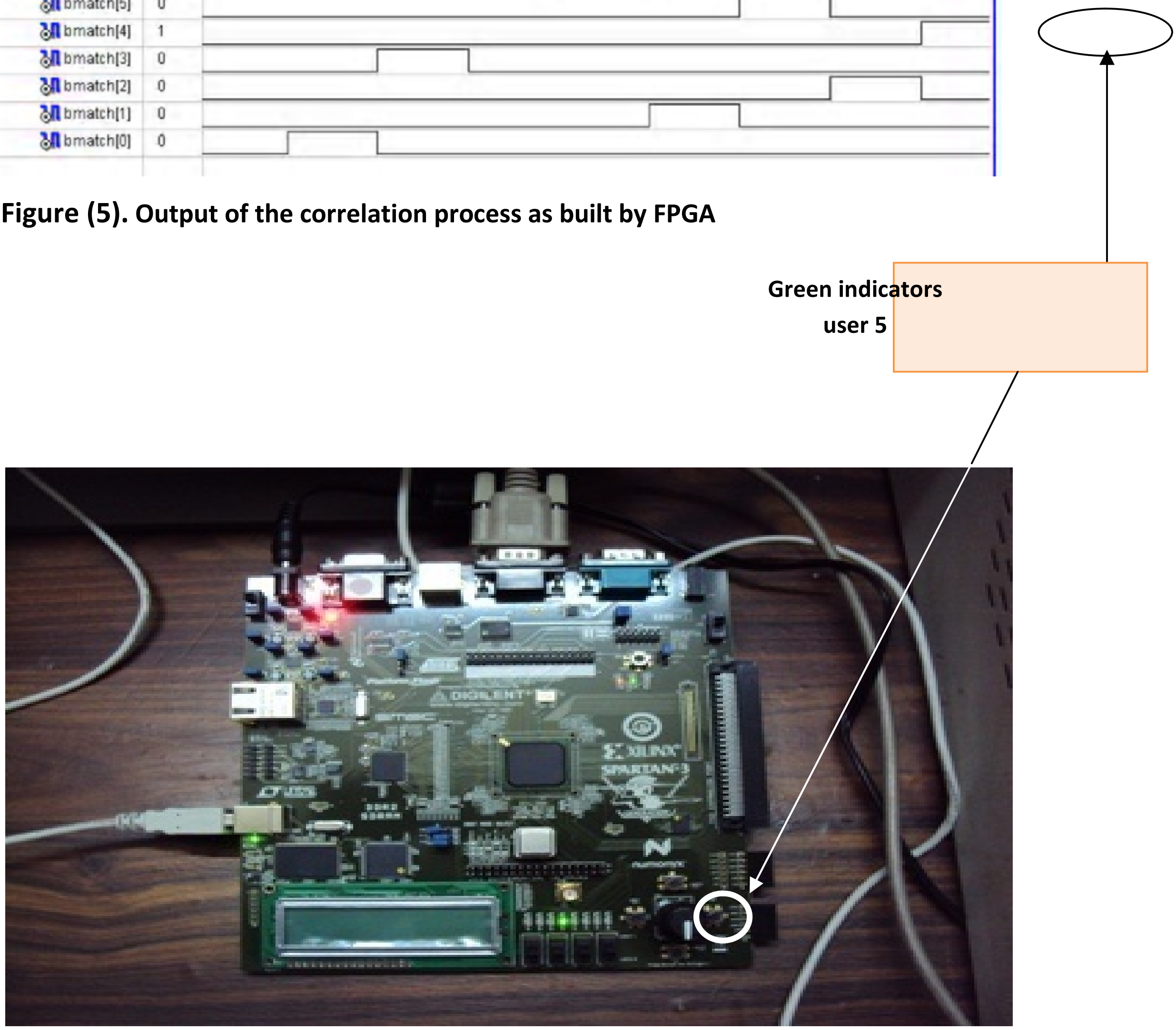


Figure (6) The implementation Circuit

BSIC غير مشكوك فيها لخلايا البيكو واسعة المساحة بأستخدام متتابعات غولي

أ.م.د ثامر رشيد سعيد م. أيفان عبد الزهرة م.د. سمير عبد الخالق م. وسام علي
م. قصي سالم توفيق

المستخلص

تستخدم نظم الاتصالات اللاسلكية بيكوسيل واحدة على الاقل ضمن ماكروسيل . أن استخدام بيكوسيل يعطي العديد من المزايا والفوائد لمنظومة الاتصالات اللاسلكية كتوفير الطاقة المشعة وزيادة قابلية المنظومة وكذلك لسد الفجوات و الثغرات الغير مغطاة إشعاعيا. ولكن في حال كون المنظومة منتشرة على مساحة واسعة وهناك تداخل لعدد كبير من بيكوسيل لذا يكون اعادة استخدام نفس الترميز والتردد امرا واردا. وبالتالي الجوال المشترك بسعة في هذه المساحة الواسعة الى مقصده سوف يكون تقريره مشكوكا فيه بسبب استخدام رمزه في مكان اخر. نقطة العمل المثلى لتركيبة المنظومة اعلاه تم الحصول عليها من خلال تحليل توزيع الخلايا. يقدم البحث خوارزمية جديدة لتصنيف الجوال المشترك وفقا لسعة حركته (ضيقة او واسعة) ويقدم استخدام ترميز كولي لذي الحركة الواسعة. كذلك يقدم البحث دائرة متابعة المستخدم لغرض اتخاذ قرار التسليم عند الحاجة بشكل دقيق. الدقة تحققت باستخدام ترميز كولي ودقة المتابعة والملاحقة وكذلك بناء دائرتي المتابعة وترميز كوليباستخدام تقنية البوابات المبرمجة موقعيا Xilinx-spartan-3A XC3S700AFPGA وبنبضة تشغيل داخلي 50 MHz ساعد بزيادة السرعة العمل و الدقة.