

# Dedication

To my parents ... ..

The two lights of my life  
Who gave me alot ,  
and miser me not.  
To all those whom I love.

## Acknowledgement

First, I would like to thank Allah, the Merciful, for giving me the power and health to do this work.

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## **Abstract**

A femtocell is a small cellular base station recently developed which designed for use in residential or small business environments. Femtocell technology has drawn considerable attention as a cost-effective mean to improve cellular coverage and capacity. Data loading and offloading to the macro Base Station (mBS) is supported through internet backhaul (IP broadband network) which exhibits the

uniqueness of this technology. However the IP broadband network is usually owned and managed by third party and not by the mobile operator, which complicated the synchronization. Synchronization is one of the most significant issues in femto-cellular networks to guarantee an acceptable clock offset and skew, which leads to severe interference between femtocell BSs and/or between femtocells BS and macrocell BSs, where both are working in same frequency under a licensed spectrum. Recently some existing algorithms and techniques have been developed in order to synchronize the clocks, and one of them (more recent) MS-Assisted Receiver-Receiver Time Synchronization Strategy for femtocell. But this strategy is not fully covered in all situations if there has no Mobile Station for a long time in any of fBS network and make network overhead by generating the message flooding for a large number of fBS node. In this research, lightweight synchronization scheme is proposed which functions through intra-cluster and inter-cluster synchronization scheme and added between them as enhancement intermediate nodes selection if the Cluster Head cannot see neighbor CH and by using the Hybrid Wireless Mesh Protocol (HWMP) to select one intermediate node, and so we get the best way to access neighboring CH to update clocks and synchronize the clusters. The proposed scheme provides high scalability and works in a decentralized manner which can support a large number of

fBS networks with a satisfactory performance level in term of synchronization accuracy. The proposed lightweight inter-cluster synchronization scheme is compared with the MS-Assisted Receiver-Receiver time synchronization strategy for femtocells. The analytical results show that synchronization accuracy can be achieved up to 60% higher than MS-Assisted Receiver-Receiver time synchronization strategy for femtocells.

## المستخلص

## الخلية متناهيه الصغر

في بيئات العمل الصغيره أوالسكنيه. ونظرا لفعاليتها من حيث التكلفة في تحسين السعة والتغطية للاتصالات الخلوية جذبت تقنية الخليه متناهيه الصغر الكثير من الاهتمام حيث تسمح بتحميل و تفريغ البيانات إلى محطة القاعدة الماكرو من خلال الإنترنت(شبكة بروتوكول الانترنت ذات النطاق العريض) والذي يعطي التفرد لهذه التقنية, ومع ذلك شبكة بروتوكول الانترنت ذات النطاق العريض عاده ماتكون مملوكه ومداره من قبل طرف ثالث وليس فقط مشغلي الهاتف المحمول ممايقعد عمليه التزامن. التزامن يعتبر أحد أهم القضايا في شبكة الاتصالات الخلوية المتناهيه الصغر و ذلك لأن التزامن يضمن للساعة إزاحة وانحراف مقبولين. التداخل هو أحد التحديات التي تظهر بسبب عدم تزامن محطات القاعده المتناهيه الصغر فمن المعروف أن محطات القاعدة المتناهيه الصغر و محطات القاعدة الصغيره تعملان على نفس التردد تحت الطيف المرخص وبالتالي يمكن أن تتداخل محطات القاعدة المتناهيه مع محطات القاعدة الصغيره كما أنه يمكن أيضاً أن تتداخل محطات القاعده المتناهيه الصغر مع بعضها البعض إذا كان هناك عدة وحدات متقاربة. مؤخراً تم تطوير بعض الخوارزميات والتقنيات لمزامنة الساعات, وواحد منهم (الاحداث) مخطط مزامنه الوقت باستخدام الهاتف المحمول لكن هذا المخطط لايقدم لنا تغطيه كامله في جميع الحالات حيث انه لازمان لوجود هاتف محمول لفترات طويله في اي شبكه محطه قاعده متناهيه الصغر بالاضافه هذا المخطط يزيد من حمل الشبكه عن طريق توليد فيض من الرسائل وذلك عند وجود عدد كبير من محطات القاعدة المتناهيه الصغر . في

هذه الأطروحة تم اقتراح مخطط تزامن المجموعات المجمله خفيف الوزن(الشفاف) و الذي يعمل من خلال المجموعات ,ومخطط تزامن المجموعات البينية و المجموعات المجمله, واضيف بينهما اختيار عقد وسيطه وذلك في حال ان العقده الرئيسيه لم تتمكن من الوصول الى جارتها العقده الرئيسيه وكذلك تم استخدام بروتوكول التوجيه للشبكات الاسلكيه الهجينه لاختيار عقده واحده ذات افضل مسار لتحديث ومزامنه الساعات المجاوره. مخطط التزامن خفيف الوزن يهدف بشكل رئيسي على خفض خطأ توازن وانحراف الساعة وكذلك مقدار الحمل للرسالة. المخطط المقترح يقدم قابلية عالية و يعمل بطريقة غير مركزية كما أنه قابل للتكيف مع عدد كبير من شبكات محطة القاعدة المتناهيه الصغر مما يضمن أداء مرضيا لدقة التزامن. في التقرير النتيجة تُظهر أن دقة التزامن أفضل بنسبة ستين بالمئة بالنسبة إلى الأعمال السابقه (مخطط مزامنه الوقت باستخدام الهاتف المحمول).

## Contents

Dedication.....	I
Acknowledgment.....	II
Abstract.....	III
المستخلص.....	V
Contents.....	VI
I	
List of Tables.....	X
List of Figures.....	XI
List of	
Abbreviations.....	XIV
<b>Chapter 1 : Introduction.....</b>	<b>1</b>
1.1 Preface .....	2
1.2 Problem Statement.....	<b>3</b>
1.3 Aim and Objectives.....	<b>3</b>
1.4 Methodology.....	3

1.5 Thesis Outlines.....	4
<b>Chapter 2: Literature Review.....</b>	<b>6</b>
2.1 Introduction.....	7
2.1.1 The Indoor Coverage Challenge.....	<b>7</b>
2.1.2 History of Femtocells.....	8
2.1.3 Femtocell Architecture .....	<b>9</b>
2.2 Femtocell Network Challenges and Issues .....	<b>11</b>
2.3 Time Synchronization Protocol and Schemes.....	12
2.3.1 Network Time Protocol .....	12
2.3.2 IEEE 1588 Timing Protocol.....	13
2.4 Synchronization Schemes.....	16
2.5 Related Work based on Clustering and Timing Synchronization.....	18
2.6 Summary.....	22
<b>Chapter 3: Methodology.....</b>	<b>25</b>



3.1 Introduction .....	26
3.2 Proposed Lightweight inter-cluster Synchronization Scheme for.....	26 Femtocell Network.
3.2. 1 Clustering Structure.....	27
3. 2. 2 Election of Cluster Head (CH).....	30
3.2. 3 Cluster Formation.....	32
3.2.4 Intra-Cluster Synchronization.....	33
3.2.4.1 Estimation of Clock Offset and Skew.....	34
3.2.5 Inter-Cluster Synchronization.....	35
3.2.5.1 Intermediate Node (IN) or CH Selection.....	35

**Chapter 4: Simulation and Result.....44**

4.1 Introduction.....	45
4.1.2 Simulator Environment.....	45
4.2 Performance Metrics.....	45

4.3 Graphical User Interface of the Lightweight Inter-Cluster.....	45
Synchronization Scheme.	
4.4 Result Analysis for lightweight Inter-Cluster Synchronization Scheme	47
4.4.1 Result Analysis for clustering scheme.....	49
4.5 Result Analysis for Intra-Cluster Synchronization Scheme.....	53
4.5.1 Average Clock Offset Analysis.....	53
4.5.2 Average Clock Skew Analysis.....	55
4.6 Comparison.....	57
4.7 Result analysis for Inter-Cluster Synchronization Scheme.....	60
4.7.1 Average Clock Offset Analysis.....	60
4.7.2 Average Clock skews Analysis.....	62
4.8 Comparison.....	64

4.9 Summary.....

..66 **Chapter 5: Conclusion and Recommendations.....68**

5.1 Conclusion .....69

5.2 Recommendations .....70

**References.....71**

**Appendixes**

## List of Tables

<u>Tables Description</u>	<u>Page Number</u>
Table 2.1: Femtocell specifications	
	9
	11

Table 2.2: Summary of literature review

22

Table 4.1: Parameters for numerical analysis

48

Table 4.2: Clock offsets and synchronization accuracy

55

Table 4.3: Clock skews and synchronization accuracy

56

Table 4.4: Clock offsets and synchronization accuracy

62

Table 4.5: Clock skews and synchronization accuracy

63

## List of Figures

<u>Figure Description</u>	<u>Page Number</u>
Figure 1: Flowchart for the general scheme	4
Figure 2.1: Femtocell network architecture	10
Figure2.2: IEEE-1588 in a femtocell base station	14
Figure 2.3: Master slave synchronization protocol	15
Figure 2.4: IEEE 1588 for femtocell network environment	16
Figure2.5: The Two Femtocell Synchronization Scenarios	17
Figure 2.6: Mobile Station assisted Synchronization scheme	16
Figure 2.7: Number of clusterheads with the number of nodes N = 450     20	
Figure.2.8: Network model for the position algorithm	21

Figure 2.9: Timing estimation procedure at each femtocell BS	
21	
Figure 3.1: Flowchart for the general scheme	26
Figure 3.2: Flat structure and Hierarchical structure	
a) Flat structure. (b) Hierarchical structure	28)
Figure 3.3: Beacon packet structure	29
Figure 3.4: Flowchart for the cluster head election	31
Figure 3.5: Flowchart for the cluster formation	32
Figure 3.6: Flowchart for intra-cluster synchronization scheme	33
Figure 3.7: Proposed intra-cluster synchronization scheme	34
Figure 3.8: Flowchart for the cluster head or intermediate node selection procedure	35
Figure 3.9: Flowchart for the intermediate node selection procedure	36
Figure 3.10: Model for the intermediate node selection	32
Figure 3.11: Flowchart for the inter-cluster synchronization scheme	39
Figure 3.12: Proposed inter-cluster synchronization scheme	41
Figure 4.1: GUI for the lightweight inter-cluster synchronization scheme	42
Figure 4.2: 100 fBS node randomly created	49
Figure 4.3: Cluster head elected for 100 fBS node	50
Figure 4.4: Cluster head section and cluster formation for 50 nodes	51
Figure 4.5: Cluster formation and INs selection for 50 nodes	52
Figure 4.6: Cluster formation and INs selection for 50 nodes after use	

## HWMP routing protocol

52

Figure 4.7: Average clock offset on different number of hops for nodes	53
Figure 4.8: Average clock offset on different number of hops for 10 nodes	54
Figure 4.9: Average clock offset on different number of hops for 10 nodes	54
Figure 4.10: Average clock skew on different number of hops for 25 nodes	56
Figure 4.11: Comparison offset of the Intra-Cluster Synchronization Scheme and conventional scheme	57
Figure 4.12: Comparison skew of the Intra-Cluster Synchronization Scheme and conventional scheme	58
Figure 4.13: Clock offset minimization in percentage for the Intra-Cluster Synchronization scheme over conventional	59
Figure 4.14: Clock skew minimization in percentage for the Intra-Cluster Synchronization scheme over conventional	59
Figure 4.15: Average clock offset on different receive delay difference in standard deviation for 5 nodes	60
Figure 4.16: Average clock offset on different receive delay difference in standard deviation for 10 nodes	61
Figure 4.17: Average clock offset on different receive delay difference in standard deviation for 25 nodes	61

Figure 4.18: Average skews on different receive delay difference in standard deviation for 25 nodes	63
Figure 4.19: Comparison offset of the Inter-Cluster Synchronization Scheme and conventional scheme	64
Figure 4.20: Comparison skew of the Inter-Cluster Synchronization Scheme and conventional scheme	65
Figure 4.21: Clock offset minimization in percentage for the Inter-Cluster Synchronization scheme over conventional	65
Figure 4.22: Clock skew minimization in percentage for the Inter-Cluster Synchronization scheme over conventional	66

## **List of Abbreviations**

3G	Third Generation
ADSL	Asymmetric Digital Subscriber Line
AODV	Ad Hoc on Demand Distance Vector
BS	Base Station
CBRP	Cluster-based Routing Protocol
CDMA	Code Division Multiple Access



CDR	Clock Drift Ratio
CH	Cluster Head
CM	Cluster Member
DAS	Distributed Antenna Systems
DSL	Digital Subscriber Line
FAP	Femtocell Access Point
fBS	femtocell Base Station
FMS	Femtocell Device Management System
FNG	Femtocell Network Gateway
FRCA	Fuzzy Relevance-based Cluster head selection Algorithm
FRD	Fuzzy Relevance Degree
FSV	Fuzzy State Viewing
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GUI	Graphical User Interface
HSDPA	High Speed Data Packet Access
HWMP	Hybrid Wireless Mesh Protocol
ICMP	Internet Control Message Protocol
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
IN	Intermediate Node
IP	Internet Protocol
LSA	Link-state Acknowledgment
LTE	Long Term Evolution
MATLABS	MATrix LABoratory
mBS	macro Base Station
M-hop	Multi-hop

MPs	Mesh Points
MS	Mobile Station
MSC	Mobile Switching Center
NTP	Network Timing Protocol
PSTN	Public switched telephone network.
PTP	Precision Timing Protocol
QoS	Quality of Service
RBS	Reference Broadcast Synchronization
SCAM	Scenario-based Clustering Algorithm for Mobile ad hoc networks
SeGW	Security Gateway
SNTP	Simple Network Timing Protocol
SOHO	Small Office and Home Office
SYNC	Synchronization Time
TDD	Time Division Duplex
UDP	User Datagram Protocol
UEs	User-Equipments
UMTS	Universal Mobile Telecommunications System
VDSL	Very-high-bit-rate digital subscriber line
WACA	Weighted-based Adaptive Clustering Algorithm
WiFi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WMASNs	Wireless Mobile Ad hoc Sensor Networks

