International Journal of Computer Applications Technology and Research
Volume 2– Issue 3, 329 - 334, 2013, ISSN: 2319–8656

Performance Analysis for Parallel MRA in Heterogeneous Wireless Networks

M.Boopathy
Ganadipathy Tulsi's Jain Engineering College
Vellore, Tamilnadu
India

V.Jayaprakasan
Ganadipathy Tulsi's Jain Engineering College
Vellore, Tamilnadu
India

Y.J.Nazeer Ahmed
Ganadipathy Tulsi's Jain Engineering College
Vellore, Tamilnadu,
India

Abstract: This paper analysis a different methods to find optimal path for services and power allocation to heterogeneous wireless network. Under heterogeneous wireless networks, a user can send data through a single or multi RATs (Radio Access Technology) simultaneously. The objective of this paper is to choose the optimal path for the services and power allocation to that bandwidth (BW) distributed joint allocation algorithm using Newton and modified Newton are adopted and the total system capacity compared. The analysis is done in Matlab and simulation results are compared. The numerical result shows that compare to Newton method, modified Newton method maximize the total system capacity.

Keywords: Access network selection, joint allocation, multi- radio access, optimization, radio resource management, RAT, MRA

1. INTRODUCTION

One of the challenges for communication network beyond 3G is the efficient interconnection of heterogeneous radio access networks. Networks with multiple radio access technologies would became one of the most prevalent features in the next generation mobile networks. These networks where a user equipment (multimode terminals) can transmit its data over multiple RATs simultaneously are named multi mode radio access (MRA) system which accommodates RATs such as WIMAX (World Wide inter operability for microwave Access), 3GPP, wireless LAN(WLAN) such equipment named as user equipment (UE) implementing cognitive radio (CR) over software defined radio (SDR). For such MRA system, optimal operation issues have taken lots of attention recently to increase system efficiency and improve connectivity and energy consumption. Optimal bandwidth (BW) and power allocation of the MRA system should be determined by Newton and modified Newton methods. Both the methods have some advantages and disadvantages in the way of finding the optimal path and energy consumption.

Several multi – access concepts may be found in the literature. In [1] joint resource allocation for parallel MRA was proposed and they compared with switched MRA methods. Allocating multiple services on the different sub – system is multi – access wireless system was discussed in paper [2]. Using straight forward maximization procedure, favorable near optimum sub – system service allocation in multi – access systems are formed. The principle role of Generic link layer (GLL) within the ambient network multi radio access architecture is to integrate different radio access technologies (RATs) at the link layer and to facilitate their efficient interworking [3].

The main benefits are user QOS gain in spectral efficiency and in robustness. Broadcasting technologies and business in base for 2.5 and 3G cellular systems, they offer numerous possibilities which always provide the user with a personal communication environment optimized for specific needs [4]. The embedding of multi – radio resources management (MRRM) mechanism fulfills a key role in enhancing system capacity, resources efficiency, and coverage and service quality [5].

A joint congestion control, channel allocation and scheduling algorithm for multi – channel multi – interface multi – hop wireless is discussed [6]. Dynamic allocation of spectrum prior to transmission is an important feature for next generation wireless networks was discussed in this paper [7]. The FDMA – capacity algorithm is used to devise the optimal frequency – division duplex plan for very high – speed digital subscriber lines [8]. Frequency spectrum a limited source for wireless communications may become congested. So which need to accommodate the diverse types of air interface used in next generation wireless networks [9]. Target MRA architecture has been proposed and characterized by access selection that would be based on load information. Additionally this architecture supports distribution of control so data as to follow for the co – operation among network operator [10]. To estimate the signal parameters accurately for mobile systems, it is necessary to estimate systems propagation characteristics through a medium [11].

2. SYSTEM MODEL

As shown in Fig.1.We considers MRA system model based on heterogeneous wireless networks. It consist of many subsystem (i.e. radio interfaces) available for each MMT(Multimode, multi band user terminal) by implementing cognitive radio (CR) over software defined radio (SDR) technology [9].The presence of multi radio access techniques(RAT)is able to improve the total system performance is known as RAT diversity.

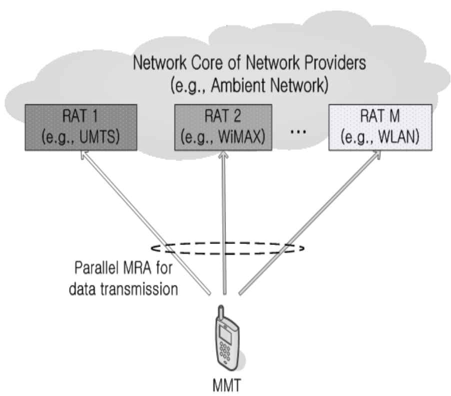

Figure.1 Parallel MRA System

Each MMT has capable of transmitting data through different RATs and operating bandwidth. Each subsystem has its own operating frequencies and its bandwidths. In MRA system data can be transmitting through switched or parallel MRA [1].

3. PROBLEM FORMULATION AND OPTIMALITY COND ITIONS

Heterogeneous wireless network is shown in figure. There are L MMT and k RATs. Based up spectrum demand, RATs q provides bandwidth units to the L MMTs. After allocating bandwidth, each MMT experiences different channel gain on each bandwidth. The channel gain to noise ratio for MMT p and RAT q can be indicated by

$$c_{pq} = \frac{|H_{pq}|^2}{N_{pq}} \tag{1}$$

Whereas H_{pq} is channel transfer function, N_{pq} is total noise power spectral density. Let bpq be the bandwidth obtained by MMT p from RAT q. each MMT q transmits his data over bandwidth bpq at rate. Therefore from Shannon capacity formula for Gaussian channel.

The achievable data rate (dp) of MMT p.

$$d_p = \sum_{q=1}^{k} \beta_q b_{pq} \log(1 + \frac{c_{pq} p_{pq}}{b_{pq}}) \tag{2}$$

Whereas k is the total number of RATs an MMT p can access b_{pq} is allocated bandwidth to the MMT p from RAT q, Ppq is the transmission power to MMT p to RAT q, β_q ($0 \le \beta_q \le 1$) represents the efficiency which can be guaranteed by RAT q to MMT p.

The maximization problem for MRA allocation can be formulated as

$$(P) \max R(b,p) = \max \sum_{p=1}^{l} d_p$$

$$= \max \sum_{p=1}^{L} \sum_{q=1}^{K} \beta_q b_{pq} \log(1 + \frac{c_{pq} p_{pq}}{b_{pq}}) \tag{3}$$

Subject to

$$\sum_{p=1}^{L} b_{pq} \le B_q, \forall q \tag{4}$$

$$\sum_{q=1}^{k} p_{pq} < p_{q,} \forall p \tag{5}$$

$$b_{pq,} p_{pq} \ge 0 \tag{6}$$

Where L is the total numbers of MMTs, Bq is the total system bandwidth of RAT q and P_q is the maximum power of MMT For the optimal solution of problem (P), the Lagrangian can be formulated as

$$L(b_{pq,} p_{pq,} \lambda_q, \mu_p) = \sum_{p=1}^{L} \sum_{q=1}^{k} \beta_q b_{pq} \log(1 + \frac{c_{pq} p_{pq}}{b_{pq}})$$
$$+ \sum_{q=1}^{k} \lambda_q (B_q - \sum_{p=1}^{L} b_{pq}) + \sum_{p=1}^{L} \mu_p (P_p - \sum_{q=1}^{K} p_{pq})$$

(7)

Where λ_q and μ_p are shadow prices with non negative Lagrange multipliers. Based on the karush-kuhn-Tucker (KKT) condition for the optimization problems

$$\frac{\partial L}{\partial \beta_{pq}} = \beta_q \log(1 + \frac{c_{pq} p_{pq}}{b_{pq}}) + \beta_q b_{pq} (\frac{b_{pq}}{b_{pq} + c_{pq} p_{pq}})(\frac{b_{pq} - (b_{pq} + c_{pq} p_{pq})}{b_{pq^2}}) - \lambda_q \le 0$$

(8)

$$\beta_q \log(1 + \frac{c_{pq} p_{pq}}{b_{pq}}) + \beta_q b_{pq} (\frac{b_{pq}}{b_{pq} + c_{pq} p_{pq}})(\frac{-c_{pq} p_{pq}}{b_{pq^2}}) - \lambda_q \le 0$$
$$= \beta_q \log(1 + \frac{c_{pq} p_{pq}}{b_{pq}}) - \beta_q (\frac{c_{pq} b_{pq}}{b_{pq} + c_{pq} p_{pq}}) - \lambda_q \le 0 \tag{9}$$

$$\frac{\partial L}{\partial \beta_{pq}} = \beta_q b_{pq} \left(\frac{b_{pq}}{b_{pq} + c_{pq} p_{pq}}\right)\left(\frac{c_{pq}}{b_{pq}}\right) - \mu_q \le 0$$

$$\frac{\partial L}{\partial \beta_{pq}} = \frac{\beta_p c_{pq} b_{pq}}{b_{pq} + c_{pq} b_{pq}} - \mu_q \le 0 \qquad (10)$$

Where L is the total numbers of MMTs, Bq is the total system bandwidth of RAT q and P_q is the

$$b_{pq}\left(\beta_q \log\left(1 + \frac{c_{pq} p_{pq}}{b_{pq}}\right) - \frac{\beta_q c_{pq} b_{pq}}{b_{pq} + c_{pq} p_{pq}} - \lambda_q\right) = 0$$

$$p_{pq}\left(\frac{\beta_q c_{pq} b_{pq}}{b_{pq} + c_{pq} p_{pq}} - \mu_q\right) = 0 \qquad (11)$$

$$\lambda_q \left(B_q - \sum_{P=1}^{L} b_{pq}\right) = (0) \qquad (12)$$

$$\mu_p \left(P_i - \sum_{q=1}^{K} P_{pq}\right) = (0) \qquad (13)$$

Using (10) and (11) the relationship between BW and power allocation can be obtained

$$\frac{\beta_q c_{pq} b_{pq}}{b_{pq} + c_{pq} p_{pq}} - \mu_q \le 0$$

$$\frac{\beta_q c_{pq} b_{pq}}{b_{pq} + c_{pq} p_{pq}} = \mu_q$$

$$\beta_q c_{pq} b_{pq} = \mu_Q (b_{pq} + c_{pq} p_{pq})$$

$$\mu_q b_{pq} + \mu_q c_{pq} p_{pq} = \beta_q c_{pq} b_{pq}$$

$$\mu_q c_{pq} p_{pq} = \beta_q c_{pq} b_{pq} - \mu_q b_{pq}$$

$$p_{pq} = \frac{\beta_q c_{pq} b_{pq} - \mu_q b_{pq}}{\mu_q c_{pq}}$$

$$p_{pq} = b_{pq} \left[\frac{b_q}{\mu_p} - \frac{1}{c_{pq}}\right]^+ \qquad (14)$$

Where $[z]^+ = \max\{z, 0\}$ from this we can get optimal b_{pq} and p_{pq} value. The proposed technique Modified Newton method can be applied to b_{pq} because it is global convergence toward a local maximum than other algorithms such as steepest descent method. It's satisfy all properties such as descent property, quadratic termination property, global convergent, order of convergence i.e. p=2 [18].

Take a function

$$f(b^n_{p_q}) = \beta_q \log\left(1 + \frac{c_{pa} p^n_{p_q}}{b^n_{p_q}}\right) - \beta_q \left(\frac{c_{pq} p^n_{pq}}{b^n_{pq} + c_{pq} p^n_{pq}}\right) - \lambda^n_q \qquad (15)$$

$$f'(b^n_{p_q}) = \frac{c_{pa} p^n_{p_q}}{b^n_{pq} + c_{pq} p^n_{pq}} \left(\frac{\beta_q}{b^n_{pq} + c_{pq} p^n_{pq}} - \frac{1}{b^n_{pq}}\right) \qquad (16)$$

Whereas superscript n represent the nth iteration. And the optimal bandwidth value can be obtained by Newton method and method modified Newton respectively.

$$b^{n+1}_{pq} = b^n_{pq} - \frac{f(b^n_{pq})}{f'(b^n_{pq})} \qquad (17)$$

$$b^{n+1}_{pq} = b^n_{pq} - \frac{f(b^n_{pq})}{f'(b^n_{oo})} \qquad (18)$$

After calculating optimal bandwidth, power can be calculated using equation.12, taking the derivative with respect p_{pq} give the KKT condition corresponding to the usual water filling level (n_p) of each MMT p can be represent as

$$\frac{p^n_{pq}}{b^n_{pq}} + \frac{1}{c_{pq}} = n_p, if p^n_{pq} > 0$$

$$\frac{1}{c_{pq}} \ge n_p, if p^n_{pq} = 0 \qquad (19)$$

Let the continuously differentiable dual function for updating μ^n_p and λ^n_q value for optimal solution.

$$D(\lambda_q, \mu_p) = \max_{b,p} L(b_{pq}, p_{pq}, \lambda_q, \mu_p) \qquad (20)$$

Update the μ^{n+1}_p value for power allocation is given by

$$\mu^{n+1}_p = \left[\mu^n_p - \xi \frac{\partial D(\lambda^n_q, \mu^n_p)}{\partial \mu^n_p}\right]^+ = \left[\mu^n_p + \xi\left(\sum_{q=1}^{K} p_{pq} - P_p\right)\right]^+ \qquad (21)$$

Whereas ξ is a constant step size (ξ > 0). For update the λ_q^{n+1} value for bandwidth allocation is given by

$$\lambda_q^{n+1} = [\lambda_q^n - \xi \frac{\partial D(\lambda_q^n, \mu_p^n)}{\partial \mu_q^n}]^+ = [\lambda_q^n + \xi(\sum_{p=1}^{L} B_{pq} - B_q)]^+ \quad (22)$$

From the iteration (14)-(22) we get the optimal solution for maximize total system capacity

4. ALGORITHM

The proposed Joint Allocation Algorithm: The two algorithms presented here is used to here to calculate the optimal path to RAT p to MMT q.

4.1.1 Newton method:

1: if K=0, then

2: Initialize $b_{pq}^{(0)}, b_q^{(0)}, P_{pq}^{(0)} and \mu_p^{(0)}$

3: else

4: Calculate b_{pq}^{k+1} using Newton's Method

$$b_{pq}^{k+1} = b_{pq}^{k} - \frac{f(b_{pq}^{k})}{f'(b_{pq}^{k}}$$

5: Determine P_{pq}^{k+1} using obtained b_{pq}^{k+1} value

$$P_{pq}^{k+1} = b_{pq}\left[\frac{\beta_q}{\mu_p^k} - \frac{1}{g_{pq}}\right]^+$$

6: if the Equilibrium Value of b_{pq} and P_{pq} is obtained, then

7: Transmit data unit to the RAT(s) Using b_{pq}^{k+1} and P_{pq}^{k+1}

8: else

9 : Update μ_p^{k+1} using P_{pq}^{k+1} Information

$$\mu_p^{k+1} = [\mu_p^k + \xi(\sum_{j=1}^{M} p_{ij}^{k+1} - p_i)]^+$$

10: Feedback the b_{pq}^{k+1} information to each RAT.

11: end if

12: end if

4.1.2 Algorithm 2 at access point of RATq

1: Compute λ_q^{k+1} using b_{pq}^{k+1} information.

$$\lambda_q^{k+1} = [\lambda_j^k + \varsigma(\sum_{i=1}^{N} x_{ij}^{k+1} - X_j)]^+$$

2: Broadcast the new λ_q^{k+1} value to all MMTs.

3: k $\rightarrow$ k+1

M represents total number of MMT p can Access

b_{pq} is allocated Bandwidth to the MMT p from RAT J

p_{pq} is the Transmission power of MMT p to Rat Q

$\beta_q (0 \le \beta_q \le 1)$ Efficiency which can be guaranteed by RAT j to an MMT.

b_q is the total system Bandwidth of RAT q

p_q is the maximum from of MMT p

N is the total number of MMIs

λ_q and μ_p are Non negative Large range multipliers.

4.2 Modified Newton method

A necessary feature we need to ensure is the existence of the iterates .one way of achieving that is to replace the Newton iteration whenever $|f_k'| \le \delta$ where $\delta > 0$ for example

$$x_{k+1} = x_k - f_k/\beta$$

Where β is sign(fk') δ if |fk'| ≤ δ otherwise β= fk'. This modification alone does not ensure convergence. What is needed is something that ensure the iterates are improving. One means of defining improvement is reduction in $f(x)^2$. We could have chosen |f(x)|, but f(x)2 has the advantage of being differentiable The basic idea is to define the iterate as

$$x_{k+1} = x_k - \alpha_k f_k/\beta$$

Where α_k is chosen that $f^2_{(k+1)<} f^2$. We need something slightly stronger to prove convergence, but it is enough to choose $\alpha_k = (1/2)^j$, where j is the smallest index ≥1, such that $f(x_k + (1/2)^j f_k/\beta)^2 < f_k^2$. Determing αk is a common procedure in n-dimensional problems and more elaborate and more efficient methods are know than the simple backtracking just described. However, they also require more elaborate termination conditions.

International Journal of Computer Applications Technology and Research
Volume 2– Issue 3, 329 - 334, 2013, ISSN: 2319–8656

5. SIMULATION RESULTS

To evaluate the performance of joint resource allocation technique for maximize the total system capacity. We consider two RATs, bandwidth of 5MHz and 20MHz with same efficiency (i.e. $\beta_q = 1$ for q = 1, 2) and distance between the access point is 200metres. Total power consumed by each MMT is 20mW.

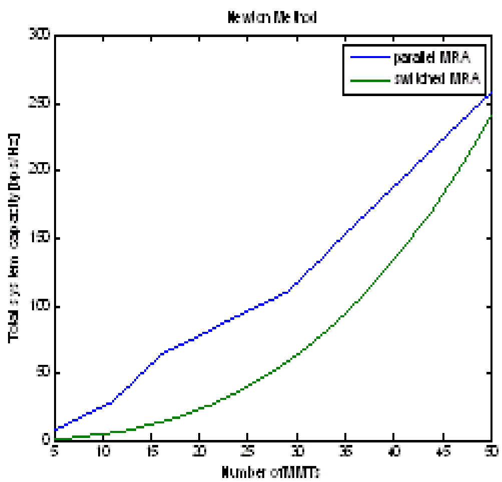

Figure.2 The comparison of parallel and switched MRA with number of MMTs using Newton method

Figure 2 shows the comparison of parallel and switched MRA with number of MMTs using Newton method. From that we concluded the total system capacity of parallel MRA is increased compared to switched MRA because parallel MRA can connect over multiple radio access technology simultaneously, whereas switched MRA can connect one radio access technology at a time. The coexistence of multi RATs enhance the total system throughput.

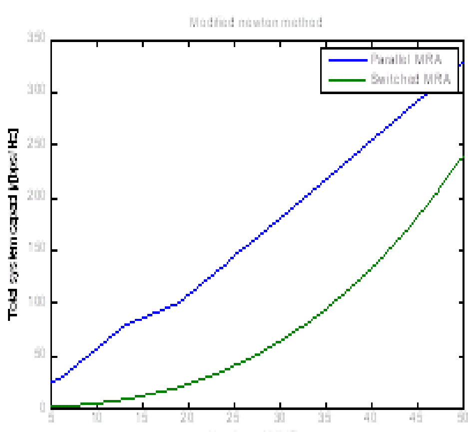

Figure.3 The comparison of parallel and switched MRA with number of MMTs using Modified Newton method

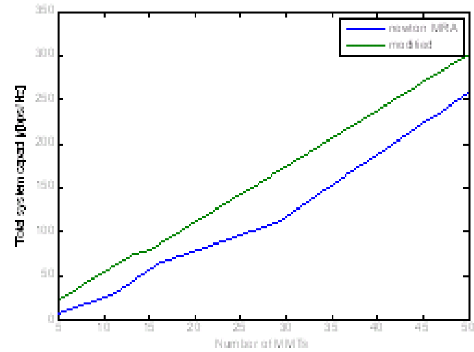

Figure.4 The comparison of parallel MRA and with number of MMTs

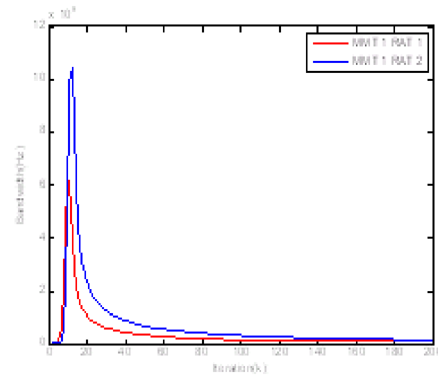

Figure .5 An illustration to how to find the optimal solution when the algorithm is applied

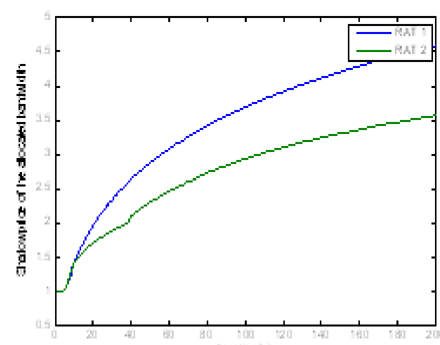

Figure.6 An illustration of the corresponding shadow price when the algorithm is applied

Figure 3. The total system capacity increases compared to the Newton method. The modified Newton converges faster towards a local maximum because Newton method is lack of global convergence property. It's satisfying all properties such as descent property, quadratic property, Global convergence and order of convergence. From Figure 4 . The total system capacity at the 25 number of MMT for Newton and modified method is 92.28 and 136.20 respectively. In modified Newton total system capacity increases up to 67% compared to the existing Newton method.

In Figure 5. Apply the algorithm to find optimal solution it can be seen that MMT 1 chose both RAT 1 and RAT 2. And chose only one RAT after iterative calculative for maximize the system capacity. Figure 13. Shows the shadow prices for the allocated bandwidth. The shadow prices increases exponential for spectrum allocated bandwidth for each MMT. Therefore in parallel MRA each MMT accessing of different RAT depend up on bandwidth and power constraints.

Table1.Comparisons of parallel MRA

TOTAL OF MMTs	NEWTON METHOD	MODIFIED NEWTON METHOD
5	7.090	21.99
10	24.790	53.96
15	56.560	79.05
20	77.950	110.76
25	88.600	129.89
30	106.450	161.67
35	138.630	193.55
40	174.000	225.59
45	209.110	257.43
50	258.000	302

6. CONCLUSION

In this paper, we analyzed the optimal solution for parallel and switched MRA scheme and two different (namely Newton and Modified Newton) joint allocation algorithm for and efficient MRA method to maximize system capacity. The simulation results shows that parallel MRA scheme is better compare to switched MRA and Modified Newton methods gives the optimal solution for the bandwidth and power usage compare to Newton method.

7. REFERENCE

[1] Yonghoon Choi, Hoon Kim, Sang-Wook Han, And Youngnam Han " Joint resource allocation for parallel multi-radio access in heterogeneous wireless networks," IEEE Transactions On Wireless Communications , Vol. 9, No. 11, Nov 2010 pp. 3324-3329.

[2] Furuskär, "Allocation of multiple services in multi access wireless systems," in Proc. International workshop Mobile Wireless Communication Network, Sep. 2002, pp. 261–265.

[3] K. Dimou, R. Agüero, M. Bortnik, et al., "Generic link layer: a solution for multi-radio transmission diversity in communication networks beyond 3G," in Proc. IEEE Veh. Technol. Conf., Sep. 2005, pp. 1672–1676

[4] E. Gustafsson and A. Jonsson, "Always best connected," IEEE Wireless Communication Lett., vol. 10, no. 1, pp. 49–55, 2003.

[5] P. Magnusson, F. Berggren, I. Karla, R. Litjens, et al., "Multi-radio resource management for communication networks beyond 3G," in Proc.IEEE Veh. Technol. Conf., Sep. 2005, pp. 1653– 1657.

[6] S. Merlin, N. Vaidya, and M. Zorzi, "Resource allocation in multi-radio multi-channel multi-hop wireless networks," in Proc. IEEE INFOCOM,2008, pp. 610–618.

[7] J. Acharya and R. D. Yates, "Dynamic spectrum allocation for uplink users with heterogeneous utilities," IEEE Trans. Wireless Communication., vol.8, pp. 1405–1413, Mar. 2009.

[8] W. Yu and J. M. Cioffi, "FDMA capacity of Gaussian multiple-access channels with ISI," IEEE Trans. Communication., vol. 50, no. 1, pp. 102–111,Jan. 2002.

[9] Ekram Hossain, Dusit Niyato, Zhu Han, "Dynamic Spectrum Access and management in Cognitive Radio networks.

[10] G.P Koudouridis, R.Aguero, E .Alexandri "Feasibility studies and Architecture for multi-Radio access in Ambient Networks".

[11] Tapan K.Sarkar, Zhong Ji ,Kyungjung kim,"A Survey of Various propagation Models for Mobile Communication".