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From the Editor

Due to the rapid advancement in science and technology the lives of people and their economic status have considerably been changed. Information technology has played a vital role in bringing about this change. Globalization of information technology has facilitated each and every sector. The investment in IT of the largest MNC's occupies considerable percentage of their budget. But the misuse of the global IT and its applications have spread serious threat to the user community. Issues like cyber crime, data security are the major challenges we are facing. The IT sector still has to prove its security concerns to achieve faithful results.

Thus today's engineers and the architects must work for maintaining secure and socio friendly technological discipline.

CONTENTS

RK-BUTCHER ALGORITHM: AN EFFICIENT APPROACH FOR SOLVING ORDINARY DIFFERENTIAL EQUATIONS

Binod Sitaula*
Dhiraj K.Das*

Abstract:

An RK-Butcher Algorithm for the analysis of second order initial value problems is presented in this paper. To illustrate the effectiveness of the algorithm, seven different kinds of problem have been considered and the solutions were obtained using the RK method based on Arithmetic mean (RKAM), Centroidal mean (RKCeM) and the RK-Butcher Algorithms and are compared with the exact solutions of those problems. Error graphs for the problems have been presented in a graphical form to show the efficiency of this RK-Butcher algorithm. This RK-Butcher algorithm can be easily implemented in any of the high level programming language on a digital computer.

Keywords: Runge-Kutta method: Arithmetic mean; Centroidal mean; RK-Butcher Algorithm Stiff and non-stiff problems.

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1. Introduction:

Mathematical modeling has been used more and more in many areas such as in science, engineering, medicine, economics, and social sciences. Differential equations are one of the important and widely used techniques in mathematical modeling. An analytical solution gives quicker and more exact solution compared to algorithmic and iterative approaches. However, not many differential equations have an analytic solution and even if there is one, usually it is extremely difficult to obtain and it is not very practical. Thus, numerical methods are truly a crucial part of solving differential equations which cannot be neglected.

Since the late 18th century, numerical methods for solving differential equations have been developed continuously by many mathematicians. Later on in the 20th century, this subject made great improvements in the context of modern computers due to the reduction in the cost of computers along with the increase in the performance. Among the models using differential equations (DEs), ordinary differential equations are frequently used to describe various physical problems, for example, motions of the planet in a gravity field like the Kepler problem, the simple pendulum, electrical circuits, chemical kinetics problems, etc.

Butcher derived the best RK pair along with an error estimate and by all statistical measures it appeared as the RK-Butcher algorithm. This RK-Butcher algorithm is nominally considered sixth order since it requires six function evaluations (it looks like it is sixth order method, but it is a fifth order method only), but in actual practice the "working order" is closer to five (fifth order) and the accuracy of results while solving the problems exceeds all the other algorithms examined including RK-Fehlberg, RK-Centroidal Mean (RKCeM) and RK-Arithmetic Mean (RKAM). In this paper, the RK-Butcher algorithm is introduced for finding the numerical solution of the second order IVPs with more accuracy.

2. RK-Butcher Algorithm:

The general p-stage Runge-Kutta method for solving an initial value problem

$$y' = f(x, y) \qquad (1)$$

with the initial condition $y(x_0) = y_0$ is

defined by $y_{n+1} = y_n + h\sum_{i=1}^{p} b_i k_i$

where $k_i = f(x_n + c_i h, y_n + h\sum_{j=1}^{p} a_{ij} k_j)$

and $c_i = \sum_{j=1}^{p} a_{ij}, i = 1, 2....., p$ with

c and b as p dimensional vectors

and $A(a_{ij})$ as the p×p matrix. Then,

the RK-Butcher algorithm of (1) is of the following form.

$$k_1 = hf(x_n, y_n)$$

$$k_2 = hf(x_n + \frac{h}{4}, y_n + \frac{k_1}{4})$$

$$k_3 = hf(x_n + \frac{h}{4}, y_n + \frac{k_1}{8} + \frac{k_2}{4})$$

$$k_4 = hf(x_n + \frac{h}{2}, y_n - \frac{k_2}{2} + k_3)$$

$$k_5 = hf(x_n + \frac{3h}{4}, y_n + \frac{3k_1}{16} + \frac{9k_4}{16})$$

$$k_6 = hf(x_n + h, y_n - \frac{3k_1}{7} + \frac{2k_2}{7} + \frac{12k_3}{7} - \frac{12k_4}{7} + \frac{8k_5}{7})$$

5th order predictor:

$$y_{n+1} = y_n + \frac{1}{90}(7k_1 + 32k_3 + 12k_4 + 32k_3 + 7k_6)$$

4th order predictor:

$$y^*_{n+1} = y_n + \frac{1}{6}(k_1 + 4k_4 + k_6)$$

Local truncation error estimate (EE):

$$EE = y_{n+1} - y^*_{n+1}$$

In similar fashion, the RKAM method is evaluated as

$$k_1 = hf(x_n, y_n)$$

$$k_2 = hf(x_n + \frac{h}{2}, y_n + \frac{k_1}{2})$$

$$k_3 = hf(x_n + \frac{h}{2}, y_n + \frac{k_2}{2})$$

$$k_4 = hf(x_n + h, y_n + k_3)$$

and $y_{n+1} = y_n + \frac{h}{6}(k_1 + 2k_2 + 2k_3 + k_4)$

For RKCeM

$$k_1 = hf(x_n, y_n)$$

$$k_2 = hf(x_n + \frac{h}{2}, y_n + \frac{k_1}{2})$$

$$k_3 = hf(x_n + \frac{h}{2}, y_n + \frac{k_1}{24} + \frac{11k_2}{24})$$

$$k_4 = hf(x_n + h, y_n + \frac{11k_1}{132} - \frac{25k_2}{132} - \frac{73}{66}k_3)$$

$$y_{n+1} = y_n + \frac{h}{6}(k_1 + 2k_2 + 2k_3 + k_4)$$

3. Numerical Examples:

To highlight the efficiency of the RK-Butcher algorithm, seven different problems have been taken from the real world applications (listed in Table 1) along with the exact solution obtained from analytical method.

S.N.	Second Order Systems	Initial Conditions	Exact Solutions
1.	Linear Equation $y'' = -y'$	$y(0) = 1$ $y'(0) = -1$	$y(x) = e^{-x}$
2.	Linear Equation $y'' = -y$	$y(0) = 1$ $y'(0) = 1$	$y(x) = e^{x}$
3.	Linear Equation $y'' = -\sqrt{2}y'$	$y(0) = -1/\sqrt{2}$ $y'(0) = -1$	$y(x) = -1/\sqrt{2}\, e^{-\sqrt{2}x}$
4.	Oscillatory Equation $y'' = y'\cos(x) - y\sin(x)$	$y(0) = 1$ $y'(0) = 1$	$y(x) = e^{\sin x}$
5.	Non-Linear Equation $(y+1)y'' = 3(y')^2$	$y(1) = 0$ $y'(1) = -1/2$ for x>1	$y(x) = 1/\sqrt{x} - 1$
6.	Singular System $\begin{pmatrix} 0 & 0 \\ 0 & 2 \end{pmatrix} y'' = \begin{pmatrix} 1 & 0 \\ 2 & 1 \end{pmatrix} y'$	$y_1(0) = 2 \quad y_2(0) = 1$ $y_1'(0) = 0 \quad y_2'(0) = 0$	$y_1(x) = 2$ $y_2(x) = -1 + 2e^{x/2}$
7.	Stiff System $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} y'' = \begin{pmatrix} -40 & 3 \\ 0 & 0.4 \end{pmatrix} y'$	$y_1'(0) = 0.5 \quad y_1(0) = 1$ $y_2(0) = 1 \quad y_2'(0) = 0.5$	$y_1(x) = 0.91875 - 0.01157e^{-40x} + 0.92821e^{0.4x}$ $y_2(x) = -0.25 + 1.252e^{0.4x}$

Table 1: Second Order IVP's with exact solutions

4. Experiments and Result Analysis

The three different methods are implemented on C++ Builder program and are tested for different values of x. The result is shown in table 2.1 and 2.2. To distinguish the effect of the errors in accordance with the exact solutions, a graphical representation is given for selected values of x, using three-dimensional effect.

x	Exact Solutions	RKAM Solutions	RKAM Error	RKCeM Solutions	RKCeM Error	RK-Butcher Solutions	RK-Butcher Error
Discrete Solutions For Problem-1							
0.00	1.000000	1.000000	0.000000	1.000000	0.000000	1.00000	0.000000
0.60	0.548812	0.541266	0.007546	0.522511	0.026301	0.548811	0.000001
1.20	0.301194	0.289506	0.011688	0.273017	0.028177	0.301194	0.000000
1.80	0.165299	0.151335	0.013964	0.1426548	0.022644	0.165298	0.000001
Discrete Solutions For Problem-2							
0.00	1.000000	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000
0.60	1.822119	1.808368	0.013751	1.749396	0.072723	1.822119	0.000000
1.20	3.320117	3.281299	0.038818	3.0603853	0.259732	3.320117	0.000000
1.80	6.049648	5.965137	0.084511	5.353826	0.695822	6.049649	0.000001
Discrete Solutions For Prob-3							
0.00	-0.707106	-0.707106	0.000000	-0.707106	0.000000	-0.707106	0.000000
0.60	-0.302673	-0.293075	0.000000	-0.272941	0.000000	-0.302673	0.000000
1.20	-0.129558	-0.115840	0.009598	-0.105353	0.029732	-0.129557	0.000000
1.80	-0.055456	-0.039971	0.013718	-0.040666	0.024205	-0.055455	0.000006
Discrete Solutions For Prob-4							
0.00	1.000000	1.000000	0.000000	1.000000	0.000000	1.000000	0.000000
0.60	1.758819	1.75137	0.000000	1.72026	0.000000	1.758819	0.000000
1.20	2.539683	2.54267	0.007449	2.550868	0.038559	2.539682	0.000000
1.80	2.648114	2.677860	0.002987	2.820770	0.011185	2.648114	0.000001
Discrete Solutions For Prob-5							
1.00	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.60	-0.209431	-0.213644	0.000000	-0.219261	0.000000	-0.209430	0.000000
2.20	-0.325800	-0.331353	0.004213	-0.330974	0.00983	-0.325800	0.000000
2.80	-0.402386	-0.408410	0.005553	-0.403405	0.005174	-0.402385	0.000000

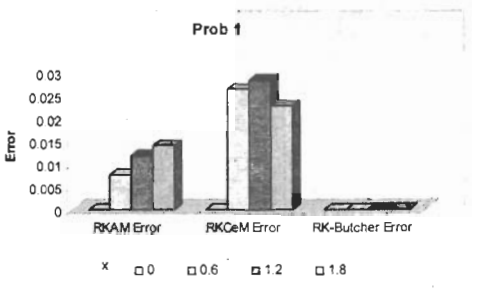
Table 2.1: Solutions and Error of the problem-(1-5) at various values of x

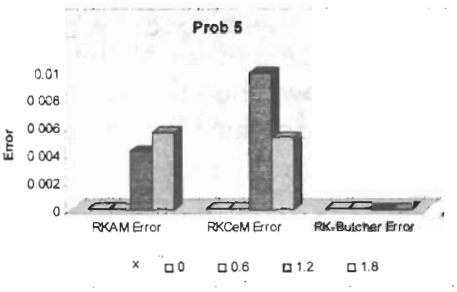
x	Exact Solutions	RKAM Solutions	RKAM Error	RKCeM Solutions	RKCeM Error	RK-Butcher Solutions	RK-Butcher Error
Discrete Solutions For Prob-6							
$y_1(x)$							
0.00	2.000000	2.000000	0.000000	2.000000	0.000000	2.000000	0.000000
0.60	2.000000	2.000000	0.000000	2.000000	0.000000	2.000000	0.000000
1.20	2.000000	2.000000	0.000000	2.000000	0.000000	2.000000	0.000000
1.80	2.000000	2.000000	0.000000	2.000000	0.000000	2.000000	0.000000
$y_2(x)$							
0.00	1.000000	1.000002	0.000000	1.000011	0.000000	1.000001	0.000000
0.60	1.699718	1.699702	2E-06	1.699017	1.1E-05	1.699717	1E-06
1.20	2.644238	2.644010	1.6E-05	2.644113	0.000701	2.644236	1E-06
1.80	3.919206	3.919210	0.000228	3.919015	0.000125	3.919203	2E-06
Discrete Solutions For Prob-7							
$y_1(x)$							
0.00	1.835398	1.83568	0.000000	1.835396	0.000000	1.835398	0.000000
0.60	2.098746	2.098754	0.000282	2.098734	2E-06	2.098744	0.000000
1.20	2.418819	2.418804	1E-05	2.418825	2E-05	2.418816	1E-05
1.80	2.825712	2.8255701	1.5E-05	2.825701	6E-06	2.825715	3E-06
$y_2(x)$							
0.00	1.002000	1.002000	0.000000	1.002001	0.000000	1.002000	0.000000
0.60	1.341604	1.341603	0.000000	1.341602	1E-06	1.341603	0.000000
1.20	1.773325	1.773314	1E-06	1.773314	2E-06	1.773323	1E-06
1.80	2.322150	2.322101	1.1E-05	2.322145	1.1E-05	2.322151	2E-06

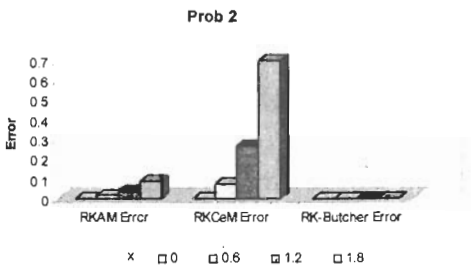
Table 2.2: Solutions and Error of the problem-(6-7) at various values of x

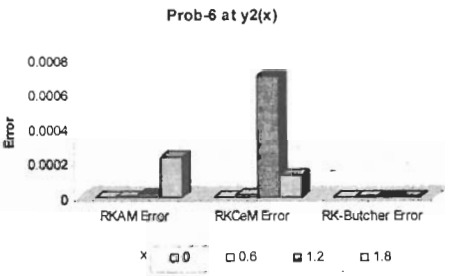
5. Error Graph:

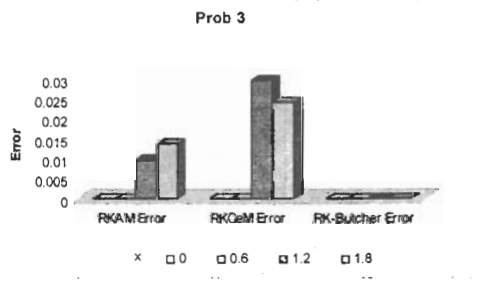
To distinguish the effect of the errors in accordance with the exact solutions, a graphical representation is given for selected values of x and is presented for all the seven problems(Problem 1-7), using three dimensional effect.

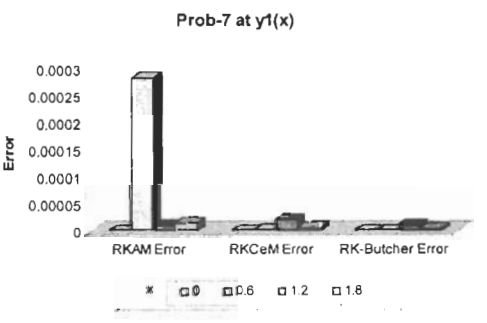

Prob 1
Error
0.03
0.025
0.02
0.015
0.01
0.005
0
RKAM Error
RKCeM Error
RK-Butcher Error
x
0
0.6
1.2
1.8

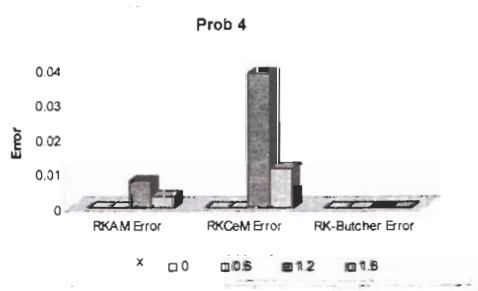

Prob 5
Error
0.01
0.008
0.006
0.004
0.002
0
RKAM Error
RKCeM Error
RK-Butcher Error
x
0
0.6
1.2
1.8

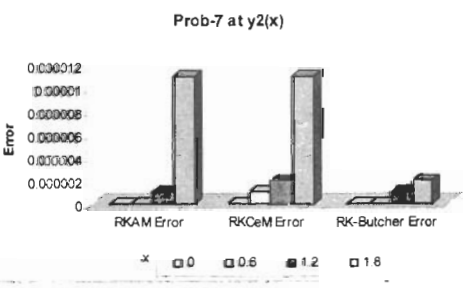

Prob 2
Error
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
RKAM Error
RKCeM Error
RK-Butcher Error
x
0
0.6
1.2
1.8


Prob-6 at y2(x)
Error
0.0008
0.0006
0.0004
0.0002
0
RKAM Error
RKCeM Error
RK-Butcher Error
x
0
0.6
1.2
1.8


Prob 3
Error
0.03
0.025
0.02
0.015
0.01
0.005
0
RKAM Error
RKCeM Error
RK-Butcher Error
x
0
0.6
1.2
1.8


Prob-7 at y1(x)
Error
0.0003
0.00025
0.0002
0.00015
0.0001
0.00005
0
RKAM Error
RKCeM Error
RK-Butcher Error
x
0
0.6
1.2
1.8


Prob 4
Error
0.04
0.03
0.02
0.01
0
RKAM Error
RKCeM Error
RK-Butcher Error
x
0
0.6
1.2
1.8


Prob-7 at y2(x)
Error
0.000012
0.00001
0.000008
0.000006
0.000004
0.000002
0
RKAM Error
RKCeM Error
RK-Butcher Error
x
0
0.6
1.2
1.8

6. Conclusion:

The obtained discrete solution of the numerical examples for all the seven problems shows the efficiency of the RK-Butcher algorithm for solving initial value problem. The analysis shows that the absolute error is less (almost no error) in RK-Butcher algorithm when compared to the classical fourth order RK -method (RKAM) and the RK-Centroidal mean (RKCeM) .From the constructed error graph also; one can predict that the error is very less in RK-Butcher algorithm when compared to RKAM and RKCeM methods. Hence, the RK-Butcher algorithm is more suitable for studying the system of different order initial value problems.

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SUSTAINABLE TOURISM PLANNING AND REGIONAL INTEGRATION: HONG KONG AND PEARL RIVER DELTA

BHATTA, Kishan Datta[1]

1. Tourism: A Theoretical Analysis

The words *travel, travel industry, tourism* and *tourist industry* all generate similar images for most people. Travel/Tourism is the action and activities of people taking trips to a place or places outside of their home community for any purpose except daily commuting to and from work. The term tourism now includes business travel as well as travel for pleasure.[2] The tourism industry is the mix of interdependent businesses that directly or indirectly serves the traveling public.

WTO defines tourism as "the activities of a person outside his or her usual environment for less than a specified period of time and whose main purpose of travel is other than exercise of an activity remunerated from the place visited". It is the most widely accepted definition around the world at present. WTO has identified the following branches of tourism:

1. Assistant Professor, Nepal Engineering College
2. Quoted from Nickerson, N.P. (1996) Foundations of Tourism

- Inbound international tourism: visits to a country by non-residents of that country
- Outbound international tourism: visits by the residents of a country to other countries.
- Internal tourism: visits by residents of a country within their own country
- Domestic tourism: Internal tourism+inbound international tourism
- National tourism: Internal tourism+outbound international tourism

However, much literature and theories define tourism in different ways. The factors which remain common to all definitions are: there must be some traveling done between origin (home) and destination, the stay at the destination should be either short term or temporary and the activities at the destination should be of leisure, recreation and educational.[3]

2. Sustainable Tourism and Eco Tourism:

Sustainability, for tourism as for other industries, has three interconnected aspects: environmental, socio-cultural, and economic. Sustainability implies permanence, so sustainable tourism includes optimum use of resources, including biological diversity; minimization of ecological, cultural and social impacts and maximization of benefits to conservation and local communities. It also refers to the management structures that are needed to achieve this.

WTO defines sustainable tourism as "Sustainable tourism development meets the needs of present tourists and host regions while protecting and enhancing opportunity for the future. It is envisaged as leading to management of all resources in such a way that economic, social, and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity, and life support systems".[4]

Clearly, sustainable tourism implies an approach to development aimed at balancing social and economic objectives with environmentally sound management. So, the sustainable tourism is mainly based on the demand and supply elements of tourism and their sustainable management and system, which can be shown by the following framework.

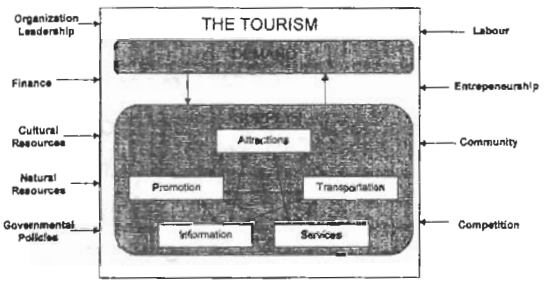

Fig: components of Sustainable tourism/system.[5]

3. Referenced from Bhattarai,A.(2004) Sustainable Tourism:Benefits for the Local Community ?, HKU Thesis MSc.(Urban Planning)
4. Source: http://www.gdrc.org/uem/eco-toureco-taur.html
5. Source: Chan, Arlen Hoi Ying (2003) Community Planning for Sustainable Tourismin Hong Kong, Case Study: Tai O Fishing Village, HKU Thesis M.Sc. (Urban Planning)

Now days, some researchers argue eco-tourism as the form of sustainable tourism, however, others argue it as an eco-terrorism. But, it is a cultural tourism (a cross-cultural experience), nature tourism (assisting with conservation programmes), a travel-learn experience (discover how we are coping with modernity), a little bit of soft adventure (just being here is an adventure), and benefiting the well-being of indigenous peoples.[6]

Within the framework of its definition of sustainable tourism, WTO has defined five basic principles of sustainable tourism:

- The natural, historical, cultural and other resources of tourism are conserved for continuous use in the future, while still bringing benefits to the present society.
- Tourism development is planned and managed so that it does not generate serious environmental or socio cultural problems in the tourism area.
- The overall environmental quality of tourism area is maintained and improved where needed.
- A high level of tourist satisfaction is maintained so that the tourist destinations will retain their marketability and popularity.
- The benefits of tourism are widely spread throughout the society.

However, the measurement of sustainability in tourism is a crucial and difficult task; some researchers have developed few indicators to measure it for policy and decision making. They provide a network for evaluating existing situation as well as future developmental activities in the field of tourist service productions. As argued by *Kreutzwister* (1992)[7], the indicators of sustainability: must be sensitive to temporal change and spatial variation, must also have predicative or anticipatory capability, should provide relative measures of conditions e.g. Population per habitat area, should include reference or threshold value and should be practical to apply.

3. Sustainable Tourism planning: Strategic and Integrated Planning Approach

The nature of sustainable tourism development requires a process of planning and management that brings together a series of interests and concerns in a sustainable and strategic form of planning and development. Tourism planning

6. Western Samoa, National Ecotourism Progr amme, Source: http:/www.gdrc.orguem/eco-tour/ecotour.html
7. Quoted from: Bhattarai, A. (2004) Sustainable Tourism: Benefits for the Local Community? HKU Thesis (MSc. Urban Planning)

continues to be contentious and somewhat nebulous, because most government's officials and tourism industry practitioners harbour their own definitions and parameters of the task. By its very nature, planning is multidimensional and is purposely integrative.[8] Hence, tourism planning needs to encompass several aspects, such as, economic, social, physical, and ecological and environmental issues with optimal utilization of both natural and artificial resources. Thus, the need for an integrated approach of planning and integrating tourism at the planning and programming stage[9] is felt for a sustainable tourism development. Tourism planning is now necessary to be incorporated into the mainstream of sustainable development framework through conscious, strategic and integrated planning[10].

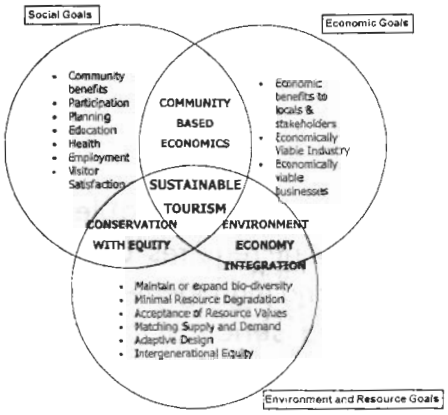

Fig: Components of Sustainable Tourism Planning (Chan:2003).

Hence, planning approaches span a broad spectrum, ranging from a rational lockstep approach all the way to strategic, broad based plans and requires careful consideration of the goals and principles of sustainable tourism so as to reflect the issues regarding economic, social, ecological, cultural and political dimension of tourism. A strategic tourism planning that seeks an optimal fit between the system and its environment is essential which really integrates the disparate planning and development activities related to tourism into an overall broad tourism plan for directing tourism in a sustainable way.

The integration within each of the levels and across all levels of strategic planning is necessary so as to achieve balance, aesthetic harmony, cooperation, confidence (for investment), efficiency, identity, sensitivity and most importantly sustainability. These aspirations of integration can be achieved through preparation of a systematic tourism policy that constitute objectives to achieve sustainable development including the sectors: Energy and water conservation, employment, economic growth, infrastructure plans, environment and resource

8. Source: Sustainable Integrated Tourism Planning, website: www.unescap.org/ttdw/Publications TPTS_pubs/Pub_2019/pub_2019_ch1.pdf
9. UN report, 1976, ECE Planning and Development of Tourism Industry in ECE region. Quoted from: Sustainable Integrated Tourism Planning, web site: www.unescap.org/ttdw/Publications TPTS_pubs/Pub_2019/pub_2019_ch1.pdf
10. Ibid.

conservation, urban and rural revitalization, heritage conservation, consumer protection, community welfare and business creation. The policies must help to coordinate government activities related to tourism and allow the public sector to take a leadership role by supporting the needs of tourists, residents and tourism businesses with appropriate legislation and administration.[11]

An important element in any tourism plan is the degree to which it is integrated with the nationwide or region-wide economic, welfare and physical development plan. It is better to integrate the site area, destinations, regional and national level areas in a plan with the help of better land use planning and the tourism planning process really provides the catalyst for inputs from the various stakeholders with the outcome of decisions affecting tourism development. So, effective institutional framework is needed to coordinate, efficiently supervise, monitor and integrate into the overall scope of national economic, environmental and social planning. The public sector, private sector, non-profit organizations, the community and tourists may act as a planner and play an important role in tourism planning and development while the professionals and experts act as their facilitator and guide, but have critical and significant role in site development and design.

4. Sustainable Tourism Planning in Hong Kong: An Overview

The tourism industry is one of the major economic pillars of Hong Kong. In 2005, the total tourism expenditure associated to inbound tourism amounted to HK$105.7 billion. Arrivals in the year were record high, with 23.4 million visitors, representing a 7.1% increase over 2004. In particular, arrivals from the Mainland grew strongly with 11.1% growth while arrivals from some major markets led a more moderate pace of growth such as South & Southeast Asia (+10.8%) and the Americas (+4.1%).[12]

Hong Kong has many attributes which have led to its development as a world-class tourist city in the Asia Pacific. In terms of transport, Hong Kong is conveniently linked by air to all major cities worldwide and serves as the major gateway for travels to the Mainland. Half the world's population lives within five hours' flying time of Hong Kong. It's free-port status also makes it one of the most attractive shopping destinations in the world[13].

11. Referenced from: Sustainable Integrated Tourism Planning, web site: www.unescap.org/ttdw/Publications TPTS_pubs/Pub_2019/pub_2019_ch1.pdf
12. Source:Tourism in Hong Kong: 2006, Google search.,
13. Ibid.

The tourism industry of Hong Kong is mainly based on business, shopping, dining and recreation, but less on its nature and culture. So, its rich natural and cultural heritage can be developed into destinations for local and international tourism to satisfy the majority of tourists, however, many destinations require some form of management, conservation, infrastructure, development and promotion to make them sustainable, viable, and accessible and preserve them for future generation.

The major tourist areas, ranging from natural heritage to cultural, historical and recreational, are located in Hong Kong Island, Kowloon, New Territories and outlying islands. The magical Victoria harbor, The Peak, The Avenue of Stars, Aberdeen, Ocean Park, Museum of Coastal Defense, Modern splendor, jockey clubs, golf clubs, green city gardens, country parks, walking trails, wetlands and bird watching, ocean adventures, beaches and islands are the major destinations for tourists from long haul and short haul market.[14]

Being Asia's world city, Hong Kong's service oriented economy, rich natural and cultural heritages and main gateway to China, has provided high advantage to be developed as a hub of world's tourism industry and will be the base for its entire development.

HKTB previously HKTA, the Department of Industry and the Productivity Council in 1997 conducted a study to develop an environmentally sustainable development strategy for tourism industry. They put forward recommendations considering different sectors to be improved such as:[15]

- Environmental management with regards to: nature conservation, waste minimization, reuse and recycling, energy conservation and management, management of fresh water resources, waste water management, hazardous substances and transportation
- Sustainable training, education and public awareness, facilitating exchange of information, skills and technology related to sustainable travel and tourism and
- Land use planning and new tourism product development.

Consequently, a Sustainable Tourism Department Task Force (STDTF) was established, comprising different organization including HKTC, to serve as a facilitator. The strategy can be

14. Source: Hong Kong tourism Board, http:/www.hktourismboard.com/login.html
15. Referenced from: Chan, Arlen Hoi Ying (2003), **Community Planning For Sustainable Tourism in Hong Kong, Case Study: Tai O Fishing Village**, HKU Thesis M.Sc.(Urban Planning)

viewed as a step towards sustainable tourism, but it is fairly one sided, directed at the service sector only but minimal regards to environmental issues and the community members who receive these tourists. Under the strategy, Hong Kong thoroughly sees tourism as a system whereby it is doing its utmost in providing all facets that contribute to the supply end of the tourism. On the other hand, it is a limiting perspective when it is viewed under the light of sustainable tourism[16].

Hong Kong's tourism strategy is mainly focused on the physical built aspects of the territory. Their approach is construction and building of sites of tourists-interests in order to gain economic profit. Negative impacts seem to be ignored and planning is used in a narrow way to meet their objectives, rather than the other way around. They neglect the aspects of the social side of tourism and do not include how the intangible factors such as community and their histories contribute to the community and tourism industry as a whole[17].

However, the Government has been launching new products to attract the tourists every year. Ngong ping 360, Hongkong Wetland Park, Hong Kong Disney land, a symphony of light as well as the global marketing campaign "2006 discover Hong Kong year" and other mega events by HKTB are the significant products and activities. But the government is still lacking in terms of long-term planning strategy and vision and is not also prepared and aware for the negative impacts of tourism on the environment and Hong Kong's unique identity and culture. The infrastructures as Cruise terminal at Kai TaK, enhancement of Sai Kung and Lei Yue Mun waterfront, the central and western district enhancement project, Tsim Sha Tsui promenade beautification projects etc. may also enhance the tourism industry of Hong Kong.

The government's strategy seemed to diversify Hong Kong's attractions by building cultural and green tourism into the picture, although the government has several limitations in preserving the buildings and sites of cultural heritage (Aberdeen), their uses after upgrading seems to be ill adapted to the overall original environment.[18]

However, the Hong Kong Disney Land, Hong Kong Wetland Park and other theme parks strategy seems quite good for the Hong Kong's tourism sector at present, as they create high

16. Ibid.
17. Ibid.
18. Referenced from: Chan, Arlen Hoi Ying (2003), Community Planning For Sustainable Tourism in Hong Kong, Case Study: Tai O Fishing Village, HKU Thesis M.Sc.(Urban Planning)

rate of return with less negative impacts on nature and culture, but there always remains a risk that tourism is dynamic and the world is globalizing very fast in a competitive way, So there seems no future of such big investments if the tourists want to go to China or PRD directly.

HKTB and HKTC are working in promoting and marketing the tourism industry through policy making and implementation. The tourism commission has declared a vision : to establish and promote Hong Kong as Asia's premier international city, a world class destination for leisure and business visitors[19]. Hong Kong 2030-planning vision and strategy has raised some important issues regarding future development of tourism. The strategy seems to be focused on eco tourism, natural and cultural tourism through the sense of belonging and also enhancing the tourism with variety of attractions in Lantau Islands, Hong Kong Islands, New Territory development etc. To satisfy these visions, it would be better to focus on integrated sustainable tourism **planning with** public participation **and sustainable** policies, and their implementation for community benefit, preserving its **unique** identify, culture, environment and heritage .

The SARS situation in 2003 has also proved that Hong Kong's travel and tourism industry is vulnerable to external events. Hence, Tourism, being the main source of income and future of Hong Kong, it is necessary to promote sustainable tourism with clear and long term vision, policy, strategy and planning along with epidemic, security and disaster responsive policies so that Hong Kong always maintains its image as the Asia's world city, otherwise, the slogans of "sustainability and tourism planning in Hong Kong" will have no meaning.

5. Regional Integration with PRD: Asset to Hong Kong's Sustainable Tourism Development

The Pearl River Delta (PRD) Economic Zone, as specified by *Guangdong Province, includes Guangzhou, Shenzhen, Dongguan, Foshan, Jiangmen, Zhongshan, Zhuhai and the urban areas of Huizhou and Zhaoqing*. The Greater Pearl River Delta (GPRD) comprises the PRD plus the Hong Kong SAR and the Macao SAR."[20]

"Tourism is often a significant component in the establishment of

19. Source: Hong Kong Tourism Board, web site: http://www.hktourismboard.camlogin.html
20. Quoted from: **Contact**, (2003), Vol. I, No.3, **Opportunity Knocks-Hong Kong and The Pearl River Delta**, A bimonthly newsletter of The University of Hong Kong, Faculty of Business and Economics.

regional economic unions, and the establishments of more formal economic relations, such as free trade agreements which aim to enhance the flow of goods and services, also tend to provide increased mobility of people".[21]

Regional cooperation is now considered a means of enhancing economic development and providing economic security within regions. Similarly, after the open door policy of China, need of regional integration between PRD, Macao and Hong Kong is felt and named as GPRD to make this region as the leading centre of the world economy. "With continual growth in China's economy which will be reinforced by the country's accession to the WTO, Hong Kong is poised to derive massive benefits from integration with the Mainland, especially the flourishing PRD region. Vast opportunities exist, but there are also big challenges ahead as trade and investment become more competitive globally. The HKSAR needs to reposition itself and restructure from the traditional middleman role to become the leading business partner of the wider PRD region".[22]

Not only the secondary industries have experienced steady expansion, but the share of tertiary sectors in PRD has also enlarged to a great extent with the significant contribution generated from the tourism sector. Similarly Hong Kong is highly influenced from its hinterland PRD. The increased integration of the economies of Hong Kong and the PRD has the potential to create one of the world's economic powerhouses and this will bring huge opportunities that will benefit firms and individuals throughout the region.[23]

According to the statistics of the tourist arrivals in Hong Kong, Mainland China occupies the first rank. Hong Kong due to its unique geographical location, service based economy and its unique identity, culture and history along with good infrastructure and services may take benefits significantly serving as the gate way to China. The PRD has also great potential for tourism development due to its rich culture, nature and recreational area. "Apart from the planned tourist attractions, there are also plenty of entertainment facilities scattered within the PRD, namely shopping districts,

21. Quoted from:Wahab,S and Cooper,C (2001) Tourism in The Age of Globalisation.
22. Quoted from: Vision Hong Kong Study Group (2002), To Be the Service Metropolis of the Pearl River Delta: A Blue Print for Hong Kong, General Chambers of Commerce and Hong Kong coalition of service industries.
23. Referenced from:Ying,Ching (2003), Tourism Development in Hong Kong and Macao Under the Impact of Pearl River Delta Development: A Comparative Study, HKU Thesis Master of Arts and Contact, (2003), Vol. I, No.3, Opportunity Knocks-Hong Kong and The Pearl River Delta, A bimonthly newsletter of The University of Hong Kong, Faculty of Business and Economics.

massage parlors, nightclubs and discos. For instance, East Gate Shopping District is one of the most popular shopping areas in Shenzhen"[24]

Hence, the integration of Hong Kong with PRD and other neighboring countries will enhance the sustainable tourism in Hongkong. Consequently, Hongkong 2030 vision and strategy also emphasize the integration with PRD for tourism development. It may be better to integrate the four pillars of sustainable tourism as economic sustainability, ecological sustainability, cultural sustainability and local sustainability into a sustainable development framework with the strong vision of regional integration with PRD region, focusing on the issues as: integrated transportation and infrastructure network, planning and management issues, economic impacts, political impacts and regional tourism development.

5.1 Integrated Transportation and Infrastructure Network: Increase in the accessibility of places and improvements in basic facilities and infrastructure really support the tourism industry in the PRD region. Public and private sectors may have a greater role to construct and maintain the infrastructure network along with region's economic and social development. It really enhances flow of people and creates new tourist destinations by the expansion of transportation network. Similarly, lodging facilities, communication networks, water and power sources, security systems and positive participation of local community enhance the tourism development in the whole region. The *Hongkong-Makao-Zhuhai bridge* and and other transportation links may enhance sustainable tourism development in the whole region.

5.2 Planning and Management Issues: In Spite of the rapid infrastructure and transportation development in PRD, several regional planners have pilloried a lack of overall planning and coordination, resulting in a number of management problems. Inadequate supply and poor management of land transportation also hinder further development and integration of the whole delta, particularly applicable to the case of tourism. The insufficient communication between the two government of Hong Kong and Macau and also the PRD local

24. Chan: 2002, quated from Ying, Ching (2003), Tourism Development in Hong Kong and Macao Under the Impact of Pearl River Delta Development: A Comparative Study, HKU Thesis (Master of Arts).

authorities impose a barrier in the cross-border tourism development, which seriously affected the tourism industry in Hong Kong given that Main land China is the major source of market.

So, better coordination is necessary among different governments, private sectors and civil society, in planning and management stage so as to promote tourism in a more beneficial and sustainable way.

5.3 Integration for Economic Benefit: Guangzhou has become one of the top cities in the world having per capita income of $10,000[25]. People from the PRD and China now want to have leisure travel and Hong Kong may be the destinations for them. Hence, the integration may probably enhance the tourism development in Hong Kong. The fast development of PRD and its close relation with Hong Kong has enhanced Hong Kong's tourism industry extensively with the increase of disposal income for leisure travel, increase in the number of business travels and increase of investment in tourism development. Hongkong being the main investor, importer and exporter in the business industry of PRD, a large number of foreign investors chose Hong Kong as their intermediary, which ultimately motivated the growth of tourism in Hongkong and PRD. So, it is clear that regional integration is very much needed for sustainable tourism development.

5.4 Integration for Political cooperation: The open door policy and economic reforms of China after 1978 has enhanced tourism development in Hong Kong and PRD region extensively. However, there are some problems for entry and exit system to the different cities of China. It may cause negative impacts to the tourism industry. Hence, integration is necessary to encourage sustainable tourism development in the region, provide relaxation on border control and simplification of the travel procedures. The political cooperation, better vision and policy may improve the sustainability in the tourism industry.

5.5 Regional tourism development centre: Although, the PRD, Macao and Hong Kong have their own tourism policy, there is a need of unified and integrated tourism policy for the entire development of the region. Every sector of tourism industry in this region is interdependent to each other and influenced by the

25. Source: B.B.C. News, Nepalese Service, London.

economy, geography, politics, facilities, services and governance system of each other. An effective cooperation mechanism among the different government should be developed and also emphasize unified regional tourism centre not an isolated way.

Hence, the regional tourism development strategy and planning really promote sustainable tourism and may provide the better solution for Hong Kong to remain as the Asia's world city.

6. Conclusion:

Hong Kong has long been perceived as a safe and convenient destination internationally. Nevertheless, a number of challenges can still be identified, particularly after the Asian Financial Crisis of 1997, leading to the downturn of tourism development in Hong Kong.

While, Hong Kong can take advantage from its neighboring countries due to its good accessibility and proximity and natural ties with its hinterland, PRD provides the potential tourist sources for Hong Kong, as Mainland visitors are ranked top in Hong Kong tourist market, as Hong Kong plays a major role in attracting potential tourists to the PRD sub-region by performing as a gateway for foreigners. Despite the importance of further co-operation and integration with the PRD, Hong Kong must not neglect the significance of maintaining its unique identity as an international city as some of the biggest strengths of Hong Kong are the differences with other PRD cities but not the similarities.[26]

Hence, the only way to be successful as an Asia world city is to focus on sustainable tourism planning and development in Hong Kong through the concept of regional integration with PRD.

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8. List of Abbrebiations:

BBC	British Broadcasting Corporation
GPRD	Greater Pearl River Delta
HKSAR	Hong Kong Special Administrative Region
HKTA	Hong Kong Tourist Association
HKTB	Hong Kong Tourism Board
HKTC	Hong Kong Tourism Commission
PRD	Pearl River Delta
SAR	Special Administrative Region
SARS	Severe Acute Respiratory Syndrome
STDTF	Sustainable Tourism Department Task Force
WTO	World Tourism Organization

HOSPITAL WATER SUPPLY AND SANITARY SYSTEM: DESIGN CONSIDERATIONS

Mohan Bikram Prajapati*

Abstract:

Design of hospital water supply and sanitary system requires special considerations on health and hygiene besides maintaining stringent water quality norms. Attention is needed in accounting quantity, quality and accessibility of water in each of the essential utilities, such as, public toilets, wards, diagnostic laboratories, operation theatre, post-partum, intensive care units, pantry, floor and room heating and in the fire hydrants.

While the system must ensure twenty-four hours uninterrupted water supply, differential pipe alignment in the system by purpose and location would be imperative. As the quantity and quality of water needed in the units would be different, it would demand different pipe materials and fixtures matching with the supply standards in different units. Proper and functional waste water disposal is also a prominent consideration since it is directly related to personal, institutional and environmental sanitation. Installing maintenance appurtenances separated in each floor and in each utility would offer advantages in maintaining differential quality standards in segregated supply lines and also in undertaking prompt and speedy maintenance without disrupting the entire system. This has important implication in reducing the maintenance and management cost of the system.

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1. Introduction

Engineering services in hospital are concerned with designing, installing, operating and maintaining the systems to offer functional, safe and continuing services. Three prominent components of the system design are: (i) water supply system, (ii) waste water disposal system, and (iii) storm water drainage system.

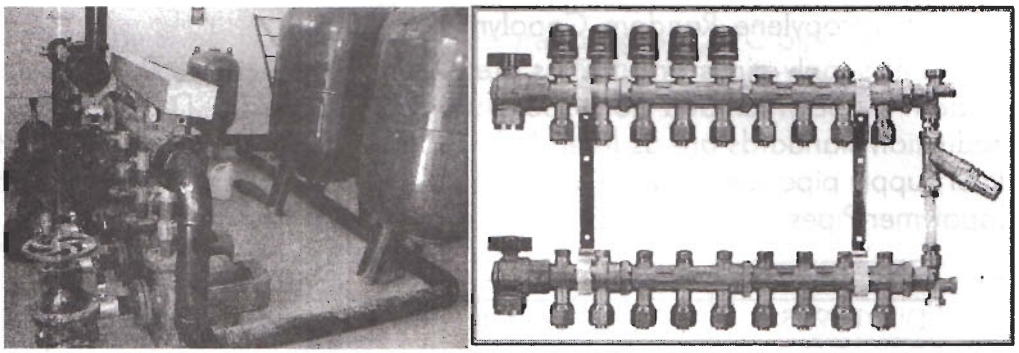
1.1 Water Supply System

The water source tapped need to be perennial, yielding continuous supply to meet all the water demands. Hospital water demand basically includes: water in the wards, outdoor patients, medical and non medical staffs, laboratory, laundry, kitchen, pantry and canteen, stair and floor washings, heating and air conditioning, waste disposal and in gardening and watering the lawns. According to National Building code of Nepal, the estimate of water requirements of hospitals includes:

- 340 liters per bed per day for hospitals having number of beds up to 100
- 450 liters per bed per day for hospitals having number of beds more than 100

The daily water requirement for a hospital is comparatively large. Gravity flow supply system requires bulk overhead storage tanks that may be uneconomical in structural design and also pose risk from seismic considerations (e.g. in old Patan Hospital building there are 7 cast iron overhead Tanks of 50000 liters capacity each). It is preferred to distribute water under pressurized supply system. However, gravity system can be adopted where 24 hours electricity supply, even with generator back up, cannot be assured.

Pressurized water supply system: The pressurized system consists of (i) booster pump (ii) pressure tank with pressure bladder, and (iii) control panel. Multiple pumps can be put in sequential operation, which can be controlled through an electronics control panel. Pressure tank can be adjusted to upper and lower limits of pressure. The pump can be made to automatically shut down when upper limit of pressure in the bladder is achieved. The lower limit is minimum pressure needed in the distribution pipelines. Upper limit depends upon pump capacity and bladder capacity and lower limit is fixed according to height of building and head losses through the pipe lines. Even in the absence of electricity, the pressure tank can supply water under the pressures between the upper and lower limits. However, the system must be backed up with electricity supply to the booster pumps with generators. The new 140 bed Patan Hospital building has been constructed with pressurized water supply system. The Booster pumps with pressure tank and manifolds in water distribution in the Patan Hospital are shown in figure 1.



i. Booster pumps and Pressure Tanks ii. Water Distribution Manifolds

Figure1. Booster pump and Water Distribution manifold in Patan Hospital

1.2 Materials for Conveyance of Water

A skillful plumber must have good knowledge on pipe materials and the basic rules in making pipe fittings. The pipe materials commonly adopted for water supply pipe lines are described below.

1.2.1 Galvanized Iron (GI) pipe

GI pipe is a wrought iron pipe coated with molten zinc. The zinc coating resists rusting, improves the appearance and permits the pipe to be soldered. The pipe needs black Japan/enamel painting to bury into ground. According to pressure bearing capacity, the GI pipes are classified into three classes:

- Light class, marked with yellow strip
- Medium Class , marked with blue strip
- Heavy Class, marked with red strip

The maximum pressure bearing capacity of GI pipe for light, medium and heavy classes are 17.2 kg per sq cm (172 m water head), 36.7 kg per sq cm (367 m water head) and 44.3 kg per sq cm (443 m water head), respectively. The codes for GI pipes and fittings and their properties are provided in Table 1 and Table 2, respectively.

I.S: 778-1984	Specification for gunmetal gate, check valves
I.S: 1239-1982	Specification for M.S. or G.I. pipes
I.S: 1879-1975	Specification for G.I. fittings

Table 2: Nominal diameter, wall thickness and unit weight of GI Pipes

Galvanized Iron pipes for ordinary uses in water supply				
Type Class	Nominal Bore (mm)	Wall Thickness (mm)	Outer Diameter (mm)	Weight of GI Pipe (Kg/m)
LIGHT 'A'	15	2	21.3	1.01
	20	2.3	26.9	1.48
	25	2.6	33.7	2.11
	32	2.6	42.4	2.72
	40	2.9	48.3	3.41
	50	2.9	60.3	4.33
MEDIUM'B'	15	260	21.3	1.28
	20	2.6	26.9	1.65
	25	3.2C	33.7	2.54
	32	3.2	42.4	3.27
	40	320	48.3	3.77
HEAVY 'C'	15	3.2	21.3	1.54
	20	3.2	26.9	1.97
	25	4	33.7	3.07
	32	4	42.4	3.97
	40	4	48.3	4.59
	50	4.5	60.3	6.39

1.2.2 Polypropylene Random Copolymer (PPR) Pipe

PPR water supply pipes and fittings are products of Type – 3 Polypropylene Random Copolymer and correspond to DIN standards: DIN 8077. The production standards are as listed below. DIN is German standard code for water supply pipe specification (SMFC Potable Water Polypropylene Random Copolymer Pipes and Fittings Catalogue).

DIN 8078	PPR pipe general quality requirements and testing
DIN 16928	PPR Pipe connections and components layout
DIN 6962	PPR Pipe joints and components
DUGW W308	Regulations and requirements for PPR pipe fittings

The PPR pipes are available in PN 16 (the pressure bearing capacity of 16 kg/cm^2) and PN 20 (the pressure bearing capacity of 20 kg/cm^2) as shown in Table 3. All the fittings are of PN 20.

Table 3: Diameter and thickness of PPR pipes

Outer Diameter (mm)	PN 16		PN 20	
	Wall thickness (mm)	Weight (kg/m)	Wall thickness (mm)	Weight (kg/m)
16	2.2	0.095	2.7	0.11
20	2.8	0.148	3.4	0.172
25	3.5	0.23	4.2	0.266
32	4.4	0.37	5.4	0.434
40	5.5	0.575	6.7	0.671
50	6.9	0.896	8.3	1.04

The joint of pipes and fittings have either threaded joints or fusion welding as directed in DIN 6962 is recommended. PPR pipes can be used for supplying both the hot and cold water.

In the New Patan Hospital Extension PPR pipes have been used for supplying water from groundwater storage reservoir to the water distribution pipe networks.

1.2.3 Chlorinated Poly-Vinyl Chloride (CPVC) Pipe

All CPVC pipes and fittings are made from identical CPVC compounds having the same physical properties. CPVC Pipes are produced in the standards of SDR 11 and SDR 13.5 meeting the requirement of ASTM D 2846 and ASTM

F 442, respectively (Table 4). The pressure rating of CPVC pipe are 28.1 kg/sq cm and 22.5 kg/sq cm for SDR 11 and SDR 13.5, respectively (Astral Flow Guard CPVC Pipes and Fittings, 2008).

Table 4: Diameter and Thickness of CPVC Pipes

Nominal Size(mm)	Outer Diameter (mm)	Wall thickness SDR 11 (mm)	Wall thickness SDR 13.5 (mm)
15	15.9	1.73	1.4
20	22.2	2.03	1.65
25	28.6	2.59	2.12
32	34.9	3.18	2.59
40	43.3	3.76	3.06
50	54	4.9	4

The joints of pipes are either threaded joints or solvent cement joints are developed as directed in above codes. CPVC pipes can be used for supplying both hot and cold water.

The developers of Valley Home in Kathmandu, in the 52 buildings developed in the first and second phases CPVC pipes have been used in supplying cold and hot water from overhead water storage tanks to the water distribution pipe net works inside the buildings.

1.2.4 Multilayer Composite (MC) Pipe

Multilayer composite pipe consists of core aluminum with inner and outer walls of plastic tightly bounded to aluminum by means of spiral adhesive. The combination of materials provides the needed strength and durability. The pipes are made of five layers. The composition of each layer is given below.

- The inside and outside layers comprise of cross linked PEX (Poly Ethylene Cross).
- An intermediate layer of overlapped welded aluminum.
- Two adhesive binding layers to bind the aluminum pipe with inner-outer layers.

The multi composite pipe is designed for cold water supply in white color and for hot water supply in red color. White colored pipes are available from 16 mm diameter to 50 mm diameter and red colored from 16 mm

to 40 mm diameter in the market. The maximum hydrostatic pressure strength of the composite ranges from 2.0 to 2.7 MPa, but the pipe is designed for a working pressure of 1.0 MPa (Table 5).

Table 5: Diameter and Thickness of Multilayer pipes

Outer Diameter (mm)	Wall Thickness (mm)	Inner Diameter (mm)	Weight (kg/m)
15.875	1.905	12.065	0.0893
22.225	2.5908	17.0434	0.1488
28.575	3.302	21.971	0.2380
34.925	4.064	26.797	0.3720
41.275	4.826	31.623	0.5207
53.975	6.2992	41.3766	0.8927

Composite pipes are joined by brass fittings and compression fittings. A brass alloy is used to manufacture all the fittings.

Multilayer Composite Pipe has been used in the internal water supply system in the Comfort Housing Tower-2 at Lazimpat and in the Comfort Housing Tower–3 at Panipokhari in Kathmandu.

All water supply pipes irrespective of materials (GI, PPR, CPVC, and Multilayer), fittings and valves need to be tested for hydrostatic pressure of at least 10 kg/cm^2. Pressure need to be maintained for a period of at least 24 hours without appreciable drop in the pressure during the test.

After thoroughly flushing the system with clean water, the system need to be filled up with a measured quantity of sodium hypochlorite solution to the water to give free residual chlorine of 5 mg/liter. After one hour of retention, the system need to be drained, re-flushed and returned to service.

2. Waste Water Disposal System

Contaminated, toxic, septic and other wastes from hospital need to be promptly disposed off into the system. Waste, soil and storm water must be disposed off through separate stacks. Door vents are provided to clean the deposited sediments. Horizontal sewers should run with sufficient slopes so that sewage could be conveyed to

manholes under gravity flow. It is preferable to use PVC pipes for waste, soil and rain water disposal as they are economical and easy to install, repair and also allow for smooth flow of sewage.

2.1 Sanitary Fixtures

Urinals: Stall type urinal for public toilet and bowl type urinal for private toilets are preferred in the hospitals. If bowl type urinals are to be installed in public toilet one or two sets needed to be of low height in order to make easy to use by the children and people with dissimilar heights.

Pan: In public toilets, pan is preferred in place of commode. In each floor a compartment to access the handicaps and a bidet for access by the children need to be provided. Stainless Steel pan is preferred than ceramic pan as it is easier for cleaning. The pan, urinal, commode and bidet should be fitted with automatically closed type flush cock otherwise they may result to non-stop flushing, causing wastage of water.

Scrub: For operation theater and post partum a stainless steel scrub is preferred than a sink. Scrub is deeper than sink and may have more than one faucet and multiple waste connections. For use in the operation theater the faucet should be either sensor operating type or arm or foot operating type (Fig. 2).

Janitor: Hospital sanitary system needs manual cleaning tools and equipments, such as floor and wall cleaning clothes, brushes, buckets, cans with handles, waste water bins, sticks etc. These equipments are stored in janitor. The janitor is provided with a tap and small platform with a floor trap. Equipments are washed and stored after use in the janitor. One unit of janitor in recommended per floor in the hospital building.

House Keeping: Bed sheets, pillow sheets, blankets and other clothes are stored and distributed from house keeping. The person handling these clothes should be clean. So house keeping unit is provided with a normal stainless steel sink without drain board.

Dirty Utility: Globe, apron, mask and small equipments are washed in dirty utilities. Dirty utility is provided with a stainless steel scrub type sink, deeper than a normal sink. Dirty utility sink is provided with both cold and hot water.

Laundry: Laundry in hospital includes a host of tasks involved in collecting, sorting dirty clothes, pre-treating, washing, drying, ironing and storing the washed clothes. The cleaned clothes are distributed to hospital wards through the house keeping. The laundry unit includes (De Chiara, Joseph and Callender, 1990):

- Storage closet
- Laundry chute (ventilated)
- Storing shelf
- Laundry tray with mixing faucets

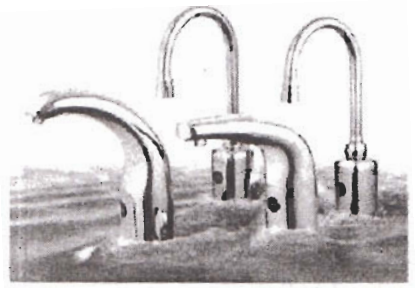
- Washers
- Dryer (ventilated)
- Ironer and pad
- Cold and hot water supply system (back up with boiler)
- Drainage system

Doctor on Call: These are the rooms where doctors stay and may hold night when they are not able to return their homes due to medical emergencies or for other responsibilities in the hospital. The room is equipped with a bed and a lavatory. The lavatory is provided with both cold and hot water supply.

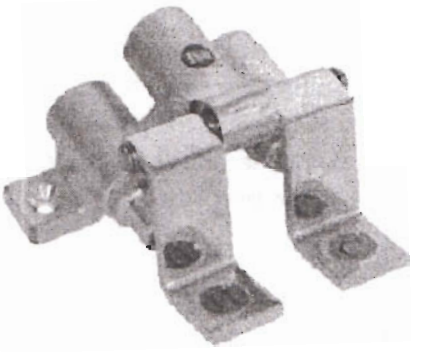
Toilet Floor: The toilet floor in the hospitals preferably should not be raised. The step to the toilet may be inconvenient to the patients. So, either toilet block is dropped by about 20 cm or false ceiling is provided beneath the toilet block to accommodate the floor trap in the toilet. The floor trap intercepts waste water from the floor, wash basin and sink.

Drinking water tap: Drinking water taps must be provided on each floor, the number depending upon the users may be as listed in Table 7. The tap is provided with a basin. Treated water is supplied through the water tap.

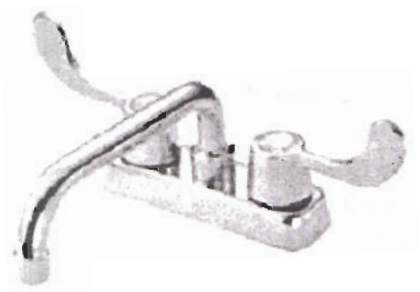
Garden tap: Garden taps are provided at 30 meter distance outside the building to water the garden. The taps are provided with nuzzled bibcock. Rubber pipes are provided to convey water from bib cock to the garden.



i. Sensor Taps



ii. Foot Valve



iii. Arm Tap

Figure 2: Valves and taps for Operation Theater

3. Storm Water Drainage System

Rain water falling on the roof, verandah, pavement, yards need to be collected and disposed off efficiently and promptly. The factors to be considered while calculating quantity of storm water are catchment

area, rainfall intensity and imperviousness factor. Free falling of rain water from the roof is not permitted. It is necessary to catch the rain water in roof gutters (for slope roof), connected with down take pipes at designed intervals. The flat roofs are also provided with some slope to permit easy drainage of water. The suggested slopes for flat roof are:

- Smooth surfaces (concrete surface with plastered and punning) : 0.5 to 0.75 %
- Normal surfaces (brick, stone, tile surface): 0.75 to 1.0%
- Rough surfaces (Gravel cobbled surface): 1.5 to 2.0 %

Inside the building the rain water vertical down take pipes should not be connected with soil or waste pipe. Bell mouth interceptors are provided to collect and deliver rainwater from the flat roof to the down take pipes. Diameters of rain water down take pipes according to catchment area and rainfall intensity are given in Table 6.

Table 6: Diameter of rain water down take pipes (NBC 208:2003)

Diameter of Down take pipe, mm	Rainfall intensity, mm/hour		
	50	75	100
	Area, square meter		
50	13.5	8.9	6.6
75	40.8	27.0	20.4
110	85.4	57	42.7
160			80.5

4. Maintenance Manual

After construction of the building and water supply and sanitary installations, a maintenance manual need to be prepared by the Sanitary Engineer involved in designing and constructing the sanitary installations. The manual should contain following information:

- Operation of the pumps including pressure pumps, if any, with priming and commissioning (the pumps may operate in parallel or sequential flow)
- Overflow and Wash out valves for water storage system (the inflow and out flow may be controlled by sensors)
- Locations of electric switches for the pumps
- Operation of water purification units
- Locations of ducts and duct details
- Locations of all control valves (gate or ball) and their regulations
- Instruction for operation of fire extinguishers and fire hydrants
- Water, waste and soil pipe rectifying, joining and replacing instructions

- Schedule of cleaning of the sanitary fixtures
- Workmanship requirements for various operations and tasks

Table 7: Sanitary fixtures requirements in hospitals

Fixtures	Indoor Patient Common Ward	Outdoor Patients Ward		Medical Staff		Non-Medical Staff	
	For male and female	For male	For female	Male	Female	Male	Female
Water Closet	1 for every 8 beds	1 for every 100 persons	2 for every 100 persons	1 for 4 persons	1 for 4 persons	1 for 25 persons	1 for 15 persons
Wash Basin	2 up to 30 beds	1 for every 100 persons	2 for every 100 persons	1 for 8 persons	1 for 8 persons	1 for 25 persons	1 for 15 persons
Urinal		1 for every 50 persons				1 for 7-20 persons, 2 for 21-45 persons	
Drinking Water Tap	1 for every 8 beds	1 for every 500 persons	1 for every 500 persons	1 for 100 persons	1 for 100 persons	1 for 100 persons	1 for 100 persons
Bath/Shower	1 for each 8 beds			1 for 4 persons	1 for 4 persons		
Bed Pan	1 for each ward						
Cleaner's Sink	1 for each ward			1 per floor	1 per floor	1 per floor	1 per floor
Others	1 Handicap closet Per floor	1 Handicap closet Per floor	1 Handicap closet Per floor				

5. Conclusion

Materials of the pipes for internal sanitary plumbing in the hospital need to be selected from hygienic point of views as well as from the considerations of ease of operation and maintenance. The sanitary fixtures installed need to be easily usable by the people and need to be easily cleanable. All types of waste water disposal system in the hospital should be simple, effective and serviceable.

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AUTONOMOUS SEARCH OPERATION STRATEGY AND APPLICATION (ASOSA)

Aditya Chauhan*, Chandra Thapa**

Abstract:

This article presents an idea on ***Autonomous Search Operation Strategy and Application*** *(ASOSA) that explains different technique to approach an autonomous search strategy and their application. Its usefulness for system integration is illustrated on an experimental robotic system in underwater rescue operation. The search and rescue operation for marine accidents require rapid response in part of the rescuers. The accident victims require quicker detection and rescue before they get drowned. There are various techniques/ algorithm to be followed for search operation with their respective magnitude. There will be deployment of definite number of submarines prior to the detection of objects/victims. The submarines use the distributed system and decentralized Swarm Intelligence (SI) to segment and investigate the assigned mishap area. The elementary purpose of ASOSA is to present an idea and construct a system capable of performing effective searching operation. Demonstration of the applicability of the distributed systems paradigm in robotic (autonomous submarine) and application of ASOSA is implicit with this article.*

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Introduction:

The recent necessity of robotics in the field of marine research as well the technological implementation in the area of disaster relating to water bodies has troubled the researchers and rescuers extremely. The trouble mainly concerns in the availability of required system and devices. In context of Nepal, the Trisuli River has experienced vehicular accidents due to numerous reasons that led to loss of life. Due to lack of proper system we are unable to even salvage the bodies of the drowned let alone rescue them. Lack of technology to use for underwater search and rescue operation is generally considered to be one of the reasons for more casualties in underwater accidents.

An algorithm *Autonomous Search Operation Strategy* (ASOS) is proposed which can be implemented in the rescuer system to search the object/victims. The effective autonomous search has its own intelligence and mutual information sharing procedure in every element. A collection of small robots (*Distributed System*) [7] submarines (hereafter subs) using the **Swarm Intelligence (SI)**[1] is used for search and identification of drowned persons or things. The ASOS is capable of *search, detection* and *identification* of targets considering the time constraint, afterward rescue is to be done by Divers. Thus, with the help of ASOS we can implement to explore the accident site (e.g.: river, pond, lake etc) and collect the *real time data* about the status of person or things inside water to take an action precisely.

The proposed system comprises of collection of medium sized robot submarines working autonomously and independently to cover the greater area of interest compared to conventional subs or human divers. The area of collective and cooperative behavior in swarm robots are emerging rapidly. The *distributed system in robotics* [7] provides the basis for the concept of ASOS. The swarm intelligence algorithm provides the basis for self governing robots with Artificial Intelligence (**AI**). The main objective of this system is for rapidly covering greater area and searching for priority targets simultaneously, governed by SI.

Swarm Intelligence:

"Swarm Intelligence (SI) is a computational intelligence technique involving the study of collective behavior in decentralized systems. Such systems are made up by a population of simple individuals interacting locally with one other and with their environment. Although there is typically no centralized control dictating the behavior of the individuals, local interactions among individuals often cause a global pattern to emerge. Examples of systems like this can be found in

nature, including ant colonies, bird flocking, animal herding, honey bees, and many more."[2]

"SI provides a basis with which it is possible to explore collective or ***distributed*** *problem solving without centralized control or the provision of a global mode".*[3]

Although the context of SI is far diverse like particle swarm optimization, ant colony optimizations, cultural algorithms or swarm robotics, the ASOS mainly focuses on Swarm Robotics. Swarm robotics involves in application of SI concept to swarm of robots. There are different algorithms that help to control the behavior of individual robots for achieving specific tasks. Among the algorithms developed like *"value iteration" A dynamic programming Algorithm* [11] [6], *Dispersion Algorithm* [8], *Dynamic capability evaluation Algorithm* [9], *Teamwork Algorithm* [10] and *DFS Exploration Algorithm* [4], each have their own advantages. Since the presented hypothesis in this article is related with *aquatic* environment and more or less with 3D movement of the subs, the stated algorithms may not be completely adequate. But by modifying them or combining their merits, we can develop a better algorithm for the system. For simplicity purpose, it can be assumed that the searching is only done in bottom of the lake making the search a 2D problem. The preliminary algorithm design opted is based on *DFS Exploration Algorithm.*

A dynamic programming Algorithm uses occupancy grid maps [11] to represent the environment. The environment is divided into *virtual cells/grid* that contains a numerical value of probability denoting obstacles at beginning. As the map is explored, along the *Frontier Cells* [11] and the values are updated among the swarm.

Dispersion Algorithm as name suggests, causes many robots to disperse in an area either systematically or randomly, trying to cover the maximum area and gather information collectively. The algorithm uses swarm to develop a tree structure so as to improve execution time of the graph-based algorithm used by the University of Minnesota's Scout [8].

Dynamic capability evaluation Algorithm is the process or the ability to assign robots a dynamic position/ work from the pool of roles to satisfy a set of stated goals [9]. The determination of the effectiveness of a robot playing a role, is based on how well its hardware and computational capabilities match the requirements of the available role. Its advantage comes forth in case of malfunction of any robot; any other robot can immediately take its place and continue the process of achieving specified objectives.

Distributed Systems in Robotics:

A distributed system consists of multiple autonomous robot-entities

that communicate through a network. The robots interact with each other in order to achieve a common goal. A computer program that runs in a distributed system is called a *distributed program* [12].

Swarm robotics [1] is a new approach that supports the coordination of multi-robot system (swarm) which consists of large numbers of relatively simple physical robots. The main goal of this approach is to study the design of robots, both their physical body and their controlling behaviors (algorithm) such that a desired *collective behavior* emerges from the inter-robot interactions and the interactions of the robots with the environment.

Autonomous System:

For decentralize and fewer human interventions, the system has to be autonomous [9]. In the real world scenario, this system requires that the subs must solve Area Search by themselves, without the help of any external system. The inclusion of central localization technique increases the complexity and cost of both hardware and software. Furthermore, the robots must search through the whole given area and accomplish the task successfully in finite amount of time.

But without external localization system, the subs will lose track of their scenario due to odometry errors and other errors in measuring distances and angles [9]. The *DFS Exploration Algorithm* presents an answer, which uses a distributed robotic system to solve Area Search without external help.

DFS Exploration Algorithm uses an assumption that robots are fault-tolerant and the search area can be segmented into interconnected polygon with sides (walls) and vertices. Mostly the algorithm takes the approach of triangulation of the polygon. It observes a depth first, on the search area, with a pair of robots remaining at every branching point, and other robots finding the third vertex with reference to the two initial branching points. The robots have set of protocols that define their movement like motion along the walls of the area, motion between branching points (vertices), etc. The figure 1 illustrates how the algorithm behaves in the given random area. The numbers indicate the order in which the triangles were covered.

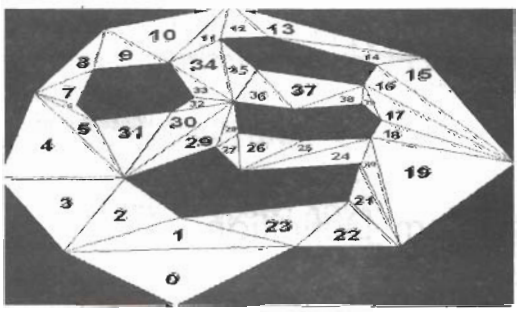

Figure 1: The order in which the DFS Exploration Algorithm covers triangles in a corridor network.

Although the DFS exploration algorithm provides the founding idea for the autonomous activity of the subs, it cannot be exactly applied to

under water scenario due to lack of real walls. The actual scenario requires the rough application of the algorithm with slight area coverage loss. The polygon assumption can be replaced by rectangles hypothesis (*Optimality in Rectangular Shapes*)[5] with area segmented by interconnected rectangle that grows as the subs cover those portion. In Wincent et al. [5] algorithm, the Unmanned Ariel Vehicles (UAVs) were designed to fly upwards and downwards in line formations parallel to the boundary of the region. In order to ensure that no target escapes into already cleaned areas, the rectangles formed by consecutive sweeps must overlap.

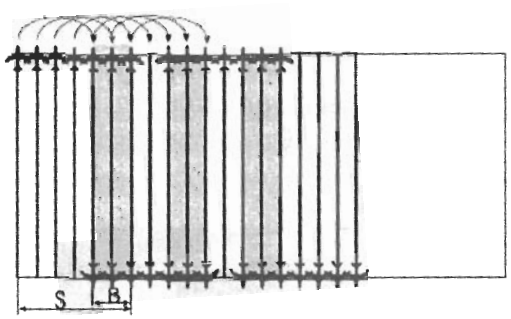

Figure 2: Illustration of the algorithm from Wincent et al.

Problem Definition:

This article display one of the various applications of distributed systems to robotics by referring a solution to the Distributed area search problem: organizing a team of subs to collaborate in the task of searching through an area. The main algorithm of the *Autonomous Underwater Research and Rescue Subs* (AURRS) system should be capable of searching the accident areas efficiently and rapidly. In this case, searching can be defined as looking for an object, human being, marine ecology, etc. The system should be sure that the robots have physically traveled within some distance of every possible location in the designated area.

"*Area Search is a superset of the Area Coverage problem and is a subset of the Area mapping problem.* [4]" For example: A robotic vacuum cleaner does *Area Coverage* and when combined with scanning processes it is *Area Search*. Area mapping means building a map of the area, which inevitably includes Area Search. The DFS Exploration Algorithm is the best root algorithm in the context of this system as it involves actual real-world scenario and every inch of the mishap area is crucial.

The construction of the sub-bots must require minimum cost with reliability and capability for swarm robotics. The mobility, power supply and communication hardware must be the major focus area of the design [13].

A Practical Example:

The overall system features and its working principle are explained in this section. The real world scenario depicting AURRS and the accident condition is as shown in figure 3.

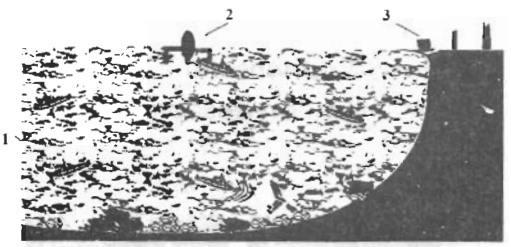

Figure 3: The diagram of real world scenario.

The system comprises of three sub-systems namely *Sub-bots(1)*, *Reference Station(2)*, and *Monitoring Unit(3)*. The sub-bots (Submarines) are the homogenous entities that constitute the swarm robots. The reference station is the docking place for the bots that deploys the bots to the scenario. It also acts as the link between the bots and monitoring unit. The operator can control (to some extent) and monitor the findings through monitoring unit.

Initially all the *sub-bots* are connected to *Reference stations*, once deployed all the subs scatter in predetermined direction so as to cover the larger possible area for searching and identification of drowned persons. The communication between the reference station and between the subs is as low as possible to apply the decentralized system tenet. The main exchange of information includes target detection and search area progress report. The algorithm keep track of each individual subs and its behavior. The *monitoring unit* collects the data from all the subs to record entire status and progress report of the mission. It also acts as human machine interface.

The experimental robotic system is planned to fulfill the main objectives like fast deployment, search and identification for rescue purpose, light weight design, and cost efficient.

Sub-bots: The system is basically collection of individual Submarine Robots (Sub-bot) operating separately but acting as a system in form of swarm applications. The external diagram of single sub-bot of the project is as shown in figure 4.

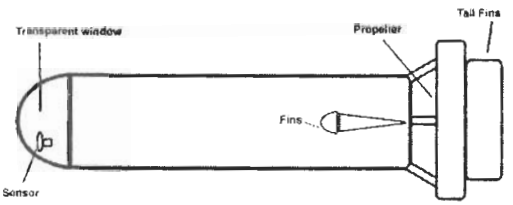

Figure 4: The diagram of single Sub-bot

The sub-bot have two lateral fins to control the diving and rising maneuver and single tail fin for left-right direction control. The main motor at the back is responsible for forward propulsion. The front head is a transparent glass and the heat or thermal sensor is placed inside the housing. The construction of the sub-bot requires that it stay in speed continuously to change direction, both left-right and up-down.

The internal block diagram of submarine robot (Sub-bot) is shown in figure 3.

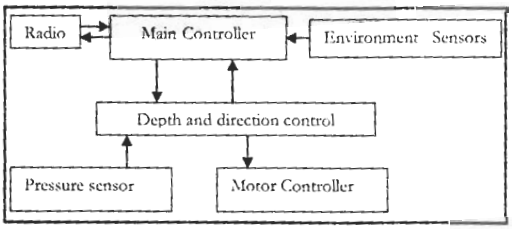

Figure 5: The internal block diagram of single Sub-bot

Reference station: The station should be constructed as to hold all subs. It must also contain relay/repeater circuits so as to transfer vital information acquired by the subs to the Monitoring Unit. For smart implementation of the swarms, the reference station can house charger block so that swarms can intelligently connect and charge their battery autonomously through reference station.

Monitoring Unit: This can be a GUI based application residing in a laptop computer with wireless adapter. The application is responsible for human machine interface. The visual cues depicting the scenario and findings will present the goal of the robotics system to more understandable form.

Prototype testing:

We have made and tested three different prototypes till date. First prototype gave us the idea of fin location and insulation. The second prototype had a better insulation and movable fin but we couldn't attain *neutral buoyancy* Neutral buoyancy makes the sub just floating enough so that when the propeller is turned on it can descend into the water.

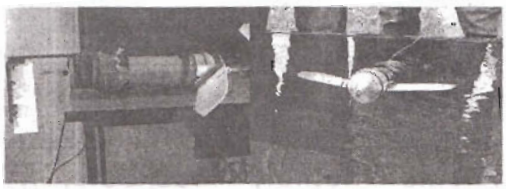

Figure 6: a) Side-view of the 3rd prototype. b) Prototype at testing ground.

The prototype was further modified to form a new model which was able to attain neutral buoyancy. Along with this modification in this prototype we made a side fin control and tail fin control for actual design. These fins are used to control the 3D direction of the sub-bots.

The initial designs in electronics consist of ultra-sonic and infrared sensors as well the microcontroller based CPU. The driver circuit and AM circuit are under construction. Software for motor control has mostly been covered.

But *currently* the system does not have any algorithm as such to be implemented. The ideas discussed earlier pave the way for the integration of possible search algorithm.

Conclusion:

Distributed automation systems in Robotics are considered from the implementation viewpoint. The two most appropriate algorithms were presented in the paper that can be implemented in real autonomous systems.

The model of the submarine was tested for movement study. Those movements and its maneuverability can be used in the simulation process. The actual system's algorithm is not constructed yet but a roadmap is presented in this article.

The standards for middleware-based automation system [14] may be used for system integration and communication that will result in reduced development time, increase interoperability, portability and reusability of automation system's components.

The system will be applicable for various purposes like rescue search operations, under water biodiversity study, marine archaeology and military purposes to name a few.

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UNIFORM VERSION OF WIENERS GENERAL TAUBERIAN THEOREMS

C. R. Bhatta*

Abstract:

The Wiener-Tauberian theorem for $\Re$ says that the closed translation invariant subspace generated by an $f \in L^1(\Re)$ is $L^1(\Re)$ if and only if the Fourier transform $\hat{f}$ of f never vanishes. In this paper we first give the proof of Wieners general Tauberian theorem and then prove the uniform version of Wieners general Tauberian theorem on real line $\Re$.

Key Words Wiener-Tauberian theorem, locally compact abelian group, translation invariant subspace.

1. Introduction:

The general tauberian theorem proved by N. Wiener [12] says that if $g \in L^1(\Re)$ is a uniqueness function in the sense that its Fourier transform $\hat{g}$ vanishes nowhere on $\Re$ (and thus the closed translation invariant subspace generated by g is $L^1(\Re)$ and $\phi \in L^\infty(\Re)$ is such that $g * \phi(x) \to A\hat{g}(0)$ (A is a complex number as $x \to \infty$ then for every $f \in L^1(\Re)$, $f * \phi(x) \to A\hat{f}(0)$ as $x \to \infty$. Here the Fourier transform of the function $f \in L^1(\Re)$ is defined by

$$\hat{f}(y) = \int_{\Re} f(x) \exp(-2\pi i xy)\, dx \text{ for } y \in \Re.$$

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For the generalization of above result for locally compact abelian group see [1], [5] and [8]. Various analogue of the Wieners-Tauberian theorem for non-abelian groups are given by Ehrenpreis and Mautner [3], Kaniuth and Steiner [6], Hauenschild, Kaniuth and Kumar [4], Sitaram [10] and others see [9] for survey.

In section 2, we obtain uniform version of Wiener Tauberian theorem for locally compact group $\Re$ replacing {g}, {f} by suitable subsets of $L^1(\Re)$, {ϕ} by suitable subsets of

$L^\infty(\Re)$. The techniques include figuringout equicontinuous subsets of $L^\infty(\Re)$ in $\|\ \|_\infty$ topology.

2. Uniform Version

Let $\Re$ be a locally compact abelian group with Haar measure μ. Here in this case Haar measure is ordinary Lebesgue measure. For basic notations and terminology, we refer to [5]. For $x \in \Re$ and $f \in L^p(\Re)$, $1 \leq p \leq \infty$, let f_x be the translate of f. Let $\phi_f: \Re \to L^\infty(\Re)$ be defined by $\phi_f(x) = f_x$, $x \in \Re$, $f \in L^\infty(\Re)$. We denote by S_1 and S_∞, the unit balls of

$L^1(\Re)$ and $L^\infty(\Re)$ respectively.

Define $U = \{g \in L^1(\Re)$: for $a \in B \cap C$, $g * a = 0 \Rightarrow a = 0\}$ where B and C are the sets of bounded and continuous function on $\Re$ respectively.

The following result 2.3 may be thought of as a uniform version of the Wiener Tauberian theorem as given in widder ([11] theorem 3.1).

Theorem 2.1 (Wieners general Tauberian theorem)

Let φ be a complex valued, measurable essentially bounded function on $\Re$. Suppose that there is a function f in $L^1(\Re)$ and complex number A such that $\hat{f}(t) \neq 0$ for all t in $\Re$ and $\int f(x-y)\,\varphi(x)\,dx \to A \int f(x)\,dx$ as $y \to \infty$, then $\int g(x-y)\,\varphi(x)\,dx \to A \int g(x)\,dx$ as $y \to \infty$ for every $g \in L^1(\Re)$.

Proof: Let φ, f and A be as in the theorem. We set $\Psi = \varphi - A$. We will prove the equivalent statement:

If $\int f(x-y)\,\Psi(x)\,dx \to 0$ as $y \to \infty$ then

(2.1.1) $\int g(x-y)\,\psi(x)\,dx \to 0$ as $y \to \infty$ for all $g \in L^1(\Re)$

But, $\int f(x-y)\,\psi(x)\,dx = \int f(x-y)\,[\varphi(x) - A]\,dx$

$= \int f(x-y)\,\varphi(x)\,dx - A \int f(x-y)\,dx$

$\to A\int f(x)\,dx - A \int f(x-y)\,dx$

$x \to x + y$

Now, $L_a f(x-y)\,\psi(x)\,dx = f(x-y-a)\,\psi(x)\,dx$

$= f(x-(y+a))\,\psi(x)\,dx$

$\to 0$ as $y + a \to \infty$ i.e. $y + a \to \infty \Leftrightarrow y \to \infty$

Therefore, $L_a f(x-y)\,\psi(x)\,dx \to 0$ as $y \to \infty$

$\Rightarrow \quad n \quad \lambda_n L_{a_n} f(x-y)\,\psi(x)\,dx = n \quad \lambda_n L_{a_n} f(x-y)\,\psi(x)\,dx$

$= n \quad \lambda_n f(x-y-a_n)\,\psi(x)\,dx$

$\to 0$ as $y + a_n \to \infty$ i.e. $y \to \infty$

This shows that 2.1.1. holds if $g = n \quad \lambda_n L_{a_n} f$.

Put $X = \{g \in L^1(\Re) : g(x-y)\,\psi(x)\,dx \to 0 \text{ as } y \to \infty\}$

We know, $n \quad \lambda_n L_{a_n} f \in X$, $\lambda_n \in \mathbf{C}$, $a_n \in \Re$ for every finite sum.

Let T be the set of all linear combinations of translates of f. By Wieners theorem we know that the linear combination of translates of f are dense in $L^1(\Re)$, so $-T = L^1(\Re)$

Clearly, $T \subseteq X \subseteq L^1(\Re)$

$\Rightarrow \quad -T \subset -X \subseteq L^1(\Re)$

$\Rightarrow \quad L^1(\Re) \subseteq -X \subseteq L^1(\Re)$

Therefore $-X = L^1(\Re)$ i.e. X is dense in $L^1(\Re)$.

X is closed: Let g_n be a sequence in X, then $g_n(x-y)\,\varphi(x)\,dx \to 0$ as $y \to \infty$, and suppose $g_n \to g$ in L^1 norm as $n \to \infty$.

Now,

$$L_y g(x)\,\psi(x)\,dx = (L_y g(x) - L_y g_n(x)\,\psi(x)\,dx + L_y g_n(x)\,\psi(x)\,dx$$

Where,

$$|L_y g(x)\,\psi(x)\,dx| = |[g_n(x-y) - g(x-y)]\,\psi(x)\,dx + L_y g_n(x)\,\psi(x)\,dx|$$

$$\leq |g_n(x-y) - g(x-y)|\,|\psi(x)|\,dx + |L_y g_n(x)\,\psi(x)\,dx|$$

$$\leq \|g_n - g\|_1\,\|\psi\|_\infty + |L_y g_n(x)\,\psi(x)\,dx|$$

Given $\epsilon > 0$ we can choose n so large that $\|g_n - g\|_1\,\|\psi\|_\infty < \epsilon/2$, and then C so large that for this n

$|L_y g_n(x)\, \psi(x)\, dx| < \epsilon/2$ for all $y > C$

Therefore, $|g_n(x)\, \psi(x)\, dx| < \epsilon$ for all $y > C$

$\Rightarrow \quad g \in X$

$\therefore$ X is closed. Hence $X = L^1(\Re)$ and we know that if $g \in X$, then $g(x-y)\, \psi(x)\, dx \to 0$ as $y \to \infty$. Since $X = L^1(\Re)$, so

$g \in L^1(\Re), g \in X \Rightarrow g(x-y)\, \psi(x)\, dx \to 0$ as $y \to \infty$.

Theorem 2.2 Let $f \in L^1(\Re)$, $\psi \in L^\infty(\Re)$. Suppose that $f(x-y)\, \psi(x)\, dx$

$\to 0$ as $y \to \infty$ and

$X = \{g \in L^1(\Re) : g(x-y)\, \psi(x)\, dx \to 0 \text{ as } y \to \infty\}$, then

X is closed translation invariant.

Proof: Let $g_1, g_2 \in X$ and α, β be any scalars then

$$(\alpha g_1 + \beta g_2)(x-y)\, \psi(x)\, dx = \alpha\, g_1(x-y)\, \psi(x)\, dx + \beta g_2(x-y)\, \psi(x)\, dx$$

$$\to 0 \text{ as } y \to \infty$$

i.e. $\alpha g_1 + \beta g_2 \in X$

$\therefore$ X is linear subspace.

Let $g \in X$, $L_a g(x-y)\, \psi(x)\, dx = g(x-y-a)\, \psi(x)\, dx$

$= g(x-(y+a))\, \psi(x)\, dx$

$\to 0$ as $y \to \infty$

$\Rightarrow \quad L_a g(x-y)\, \psi(x)\, dx \to 0$ as $y \to \infty$.

$\Rightarrow \quad L_a g \in X$

$\therefore$ X is closed translation invariant linear subspace of $L^1(\Re)$.

Theorem 2.3 (Uniform version of Wieners general Tauberian theorem)

Let $f \in L^1(\Re)$ be such that $\hat{f}(t) \neq 0$ for all $t \in \Re$. Let $u \subset S_\infty$ be the family of bounded function on $\Re$, where S_∞ is the unit ball of $L^\infty(\Re)$. Suppose that $f(x-y)\, \psi(x)\, dx \to 0$ as $y \to \infty$ uniformly for ψ in u

then for all $g \in L^1(\Re)$, $g(x-y)\,\psi(x)\,dx \to 0$ as $y \to \infty$ uniformly for ψ in u.

Proof: Since $\hat{f}(t) \neq 0$ for all $t \in \Re$ by Wieners theorem the set of all linear combination of translate of f is dense in $L^1(\Re)$. Given, $f(x-y)\,\psi(x)\,dx \to 0$ as $y \to \infty$ uniformly for ψ in u. Let $a \in \Re$ be any number then,

$$L_a f(x-y)\,\psi(x)\,dx = f(x-y-a)\,\psi(x)\,dx$$

$$= f(x-(y+a))\,\psi(x)\,dx$$

$$\to 0 \text{ as } y \to \infty \text{ uniformly for } \psi \text{ in } u.$$

Therefore, $L_a f(x-y)\,\psi(x)\,dx \to 0$ as $y \to \infty$ uniformly for ψ in u.

Thus, $n \;\; \lambda_n L_{an} f(x-y)\,\psi(x)\,dx \;\; 0$ as $y \to \infty$ uniformly for ψ in ν.

Let A = (2.1.2)

then $-A = L^1(\Re)$. Let $g \in L^1(\Re)$ be arbitrary, so $g \in -A$ i.e. g is an adherent point of A which implies a sequence $(g_n) \subset A$ such that $g_n \to g$ as $n \to \infty$ in $L^1(\Re)$.

From (2.1.2) it follows that $g_n(x-y)\,\psi(x)\,dx \to 0$ as $y \to \infty$.

Uniformly for ψ in u and for all $n \in N$ s.t. $n \geq n_o$ $\|g_n - g\|_1 < \epsilon/2$.

In particular $\|g_{n_o} - g\|_1 < \epsilon/2$ (2.1.3)

Now for the particular g_{n_o} we have,

$$g_{n_o}(x-y)\,\psi(x)\,dx \to 0 \text{ as } y \to \infty \text{ uniformly for } \psi \text{ in } u \subset S_\infty.$$

So there exists $C > 0$ s.t. $y > C \Rightarrow |g_{n_o}(x-y)\,\psi(x)\,dx| < \epsilon/2$

for ψ in u (2.1.4.)

Now, $|g(x-y)\,\psi(x)\,dx|$

$$= |\{g(x-y) - g_{n_o}(x-y)|\,\psi(x)\,dx + g_{n_o}(x-y)\,\psi(x)\,dx|$$

$$\leq |\{g(x-y) - g_{n_o}(x-y)\}\,\psi(x)\,dx| + |g_{n_o}(x-y)\,\psi(x)\,dx|$$

$$\leq |g_{n_o}(x-y) - g(x-y)|\,|\psi(x)|\,dx + |g_{n_o}(x-y)\,\psi(x)\,dx|$$

$$\leq \|\psi\|_\infty\, |L_y(g_{n_o} - g)(x)|\,dx + |g_{n_o}(x-y)\,\psi(x)\,dx|$$

$\leq \|\psi\|_\infty \|g_{n_0} - g\|_1 + |g_{n_0}(x-y)\,\psi(x)\,dx|$

$\leq 1 \cdot \epsilon/2 + \epsilon/2 = \epsilon$ for all ψ in u and $y > C$

Therefore, $|g(x-y)\,\psi(x)\,dx| < \epsilon$ for all $y > C$, ψ in u.

$\therefore$ $g(x-y)\,\psi(x)\,dx \to 0$ as $y \to \infty$ uniformly for every ψ in u. Thus $g \in A$.

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COMPARATIVE STUDY OF THERMAL PERFORMANCE OF DIFFERENT BUILDING ELEMENTS OF EXISTING TRADITIONAL AND MODERN BULDINGS OF KATHMANDU VALLEY

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Abstract:

All over the world, ancient and traditional architecture had embraced many characteristics to provide thermal comfort with better thermal performance than the modern buildings.

A building with a good thermal performance establishes a comfortable indoor environment to the occupants of the building.

The traditional buildings in Nepal used wide walls whereas the tendency in the modern residential buildings is to use nine inch walls with or without inside and/or outside plaster. Similarly very little insulation, if any, is used on the RCC terrace in the modern buildings. It is a common experience that such buildings get warmed up to uncomfortable level during the summer and become very cold during the winter.

This study looks at the study of the effect of heat transfer through walls and roofs of different types of buildings (traditional and modern buildings) using various mathematical techniques.

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Keywords: Thermal Comfort, Thermal Performance of building elements

1. Background:

In Nepal the traditional buildings employed thick walls with lime surkhi mortar and even earlier, mud mortar. The thick walls with such types of mortars had insulating effects. As a result, the buildings would not warm and cool immediately. Such buildings were thus comfortable for the inhabitants. However, with the advent of modern building technology, cement, and the practice of designing frame structures, the thickness of walls was reduced to one brick size, meaning about nine inches. Such walls, compared to thick traditional walls, have very little thermal insulation effect.

2. Methods:

To understand the thermal behavior and to arrive at meaningful findings case study of two types of existing buildings, one traditional and another modern type of building has been done.

Rajbhandari House at Kwalkhu, Lalitpur has been selected to represent one of the typical traditional buildings. Civil Homes Phase-3/ Type M has been selected as the modern building.

The study considers only the perimeter walls and the roof. The inside of the house is treated as a single zone. Heat transfer from windows, doors is not considered. This study starts by calculating overall heat transfer coefficient for typical walls/ roofs with the help of thermal and other properties of building materials.

Case Study 1: Rajbhandari House, Kwalkhu

This building is located at Kwalkhu Lalitpur.The building is rectangular in plan with load bearing system.

Fig.: View from courtyard

Built up facilities are:

i. Ground Floor / Chhyadi: served as a shop and store room
ii. First Floor / Matan: served as family room
iii. Second floor / Chota: served as the main living and Family area
iv. Top floor/ Attic space / Baiga: served as both kitchen and the family shrine.

The floor height of the building is 2.1m and consists of three and half story. Components like beams, joists, lintels,

beautifully carved doors, windows and pillars are of wood. Generally, in all the structures mud is used as mortar in between the bricks. The house utilizes different thickness of walls. Maximum thickness of wall is 610 mm burnt brick without plaster on both sides on the ground floor and thickness decreases in the succeeding upper floors. The thickness of the perimeter wall is 360 mm of unburnt brick with 110 mm of burnt brick and 25mm mud plaster on the side of the unburnt brick. The thickness of partition walls seen in succeeding floors is 110 mm thick brick wall.

The roof, which may be regarded as typical in most of the old traditional houses inKathmandu Valley has following elements:

i. Layer of chola aypa.

ii. 100 mm surface mud layer.

iii. 18 mm jhingati tile.

Study 2: Civil Homes Phase -3 / Type M

Civil Homes-Phase 3 buildings have been selected to represent the modern residential houses in Kathmandu which is located in Sunakothi at the Southern part of Lalitpur just about five minutes drive from Satdobato (Khumaltar) Chowk on the way to Chapagaun. The typical housing unit is constructed usually as a framed structure with nine inch thick perimeter wall normally with half inch cement plaster inside.

The building is rectangular in plan with RCC beam and pillar system. Built up facilities are:

Fig: Front view of Civil Homes

1. Ground Floor: Living room, dinning, Kitchen, bed room, Bath room *Phase- 3/Type M*
ii. First Floor: Master bed room with dressing and attached bath room, two bed rooms, Bathroom and Terrace
iii. Second floor: Puja room

The total built up area is 1967.47 sq. ft. with car porch of 181.5 sq. ft.area. The floor height of the building is 2.9m and is of two and half storeys. The perimeter walls are all of 230 mm brick with 12mm cement plaster inside. The partition walls are only 110 mm thick and have 12mm plaster on both sides. The house is provided with sloped roof with 12mm cement plaster, 100mm RCC slab, 19mm screed and cement tile as well as flat roof with 100mm RCC slab, 19mm cement screed and 12mm cement plaster on both side.

3. Calculations

3.1 Calculations of Thermal Transmittance value (U-Value or U) or Overall heat transfer coefficient value:

$U = 1/R_T$

where,

U= Thermal transmittance value, $W/(m^2K)$

R_T = Total thermal resistance, $(m^2K)/W$

Again,

$R_T = 1/fo+1/fi+R_1+R_2+\ldots$where,

$R = R_1, R_2, R_3\ldots$ = Thermal resistance of different materials $(m^2K)/W$ where, $R=L/k$

$L = L_1, L_2, L_3\ldots$=Thickness of different materials (m)

$k= k_1, k_2, k_3\ldots$= Thermal conductivity of different materials (W/mK)

f_o= Outside surface conductance=19.86 $W/(m^2K)$

f_i= Inside surface conductance=9.36 $W/(m^2K)$

3.2 Calculation of U-Value for wall and roof for Rajbhandari House:

i. Wall with 110mm burnt brick,360 mm sun dried brick and 25mm mud plaster

Here,

For burnt brick,

k_1 (conductivity) $=0.811$ W/(mK), L_1 (thickness $) = 0.110$ m, $\therefore$ R_1 (resis tance $)=\frac{L_1}{k_1}=\frac{0.110}{0.811}=0.1356\ (m^2K)/W$

For sundried brick, $k_2 = 0.56$ W/(mK), $L_2 = 0.360$ m, $\therefore$ $R_2=\frac{L_2}{k_2}=\frac{0.360}{0.560}=0.643\ (m^2K)/W$

For mud plaster, $k_3 = 0.200$W/(mK), $L_3 = 0.025$ m, $\therefore$ $R_3=\frac{L_3}{k_3}=\frac{0.020}{0.200}=0.125\ (m^2K)/W$

We have, $\frac{1}{f_i}=\frac{1}{9.36}=0.1068$ and $\frac{1}{f_o}=\frac{1}{19.86}=0.0504$

$\therefore R_T=\frac{1}{f_o}+\frac{1}{f_i}+R_1+R_2+R_3=1.061\ (m^2K)/W$

$\Rightarrow U=\frac{1}{R_T}=\frac{1}{1.061}=0.943$ W/(m^2K)

ii. U-value for wall with 609.60mm burnt brick

For burnt brick, $k_1 = 0.811$ W/(mK), $L_1 = 0.6096$m, $\therefore R_1 = \frac{L_1}{k_1} = \frac{0.6096}{0.811} = 0.7517\ (m^2K)/W$

and $\frac{1}{f_i} = \frac{1}{9.36} = 0.1068, \frac{1}{f_o} = \frac{1}{19.86} = 0.0504$

$\therefore R_T = \frac{1}{f_o} + \frac{1}{f_i} + R_1 = 0.909\,(m^2K)/W$

$\Rightarrow U = \frac{1}{R_T} = \frac{1}{0.909} = 1.100\ W/(m^2K)$

iii.U-value for 110mm thick burnt brick wall with 25mm mud plaster on one side

For burnt brick, k_1=0.811 W/(mK), $L_1 = 0.110$ m, $\therefore R_1 = \frac{L_1}{k_1} = \frac{0.110}{0.811} = 0.1356\ (m^2K)$

For mud plaster, $k_2 = 0.200$W/(mK), $L_2 = 0.025$ m, $\therefore R_2 = \frac{L_3}{k_3} = \frac{0.020}{0.200} = 0.125\ (m^2K)/W$

We have,

$\frac{1}{f_i} = \frac{1}{9.36} = 0.1068$ *and* $\frac{1}{f_o} = \frac{1}{19.86} = 0.0504$

$\therefore R_T = \frac{1}{f_o} + \frac{1}{f_i} + R_1 + R_2 = 0.4181\,(m^2K)/W$

$\Rightarrow U = \frac{1}{R_T} = 2.393\ W/(m^2K)$

iv.Roof with a layer of 9mm thick brick tile layer(chola aypa), 100mm surface mud layer and 18mm tile (jingati aypa)

For brick tile , k_1=0.571 W/(mK), $L_1 = 0.09$ m, $\therefore R_1 = \frac{L_1}{k_1} = 0.1576\ (m^2K)$

For mud layer, $k_2 = 0.519$W/(mK), $L_2 = 0.100$ m, $\therefore R_2 = \frac{L_3}{k_3} = 0.193\ (m^2K)/W$

For jhingati tile, $k_3 = 0798$W/(mK) , $L_3 = 0.19$ m, $\therefore R_3 = \frac{L_3}{k_3} = 0.2381\ (m^2K)/W$

We have,

$\frac{1}{f_i} = \frac{1}{9.36} = 0.1068$ *and* $\frac{1}{f_o} = \frac{1}{19.86} = 0.0504$

$\therefore R_T = \frac{1}{f_o} + \frac{1}{f_i} + R_1 + R_2 + R_3 = 0.4181\,(m^2K)/W$

$\Rightarrow U = \frac{1}{R_T} = 2.393\ W/(m^2K)$

3.3 Calculation of U-Value of wall and roof for Civil Homes

i.110mm thick brick wall with 12mm plaster on both sides (Partition Walls)

For brick wall ,

k_1=0.811 W/(mK), $L_1 = 0.110$ m, $\therefore R_1 = \frac{L_1}{k_1} = 0.136\,(m^2K)$

For cement plaster,

$k_2 = k_3 = 0.721$W/(mK), $L_2 = L_3 = 0.012$ m, $\therefore R_2 = R_3 = \frac{L_3}{k_3} = 0.0166\ (m^2K)/W$

We have,

$\frac{1}{f_i} = \frac{1}{9.36} = 0.1068$ *and* $\frac{1}{f_o} = \frac{1}{19.86} = 0.0504$

$\therefore R_T = \frac{1}{f_o} + \frac{1}{f_i} + R_1 + R_2 + R_3 = 0.326\,(m^2K)/W$

$\Rightarrow U = \frac{1}{R_T} = 3.067\ W/(m^2K)$

ii. 230mm thick wall with 12mm plaster on both sides (Perimeter Walls)

For brick wall , k_1=0.811 W/(mK), $L_1 = 0.230$ m, $\therefore R_1 = \frac{L_1}{k_1} = 0.284\,(m^2K)$

For cement plaster, $k_2 = k_3 = 0.721$W/(mK), $L_2 = L_3 = 0.012$ m, $\therefore R_2 = R_3 = \frac{L_3}{k_3} = 0.0166\ (m^2K)/W$

We have,

$\frac{1}{f_i} = \frac{1}{9.36} = 0.1068$ *and* $\frac{1}{f_o} = \frac{1}{19.86} = 0.0504$

$\therefore R_T = \frac{1}{f_o} + \frac{1}{f_i} + R_1 + R_2 + R_3 = 0.474\,(m^2K)/W$

$\Rightarrow U = \frac{1}{R_T} = 2.109\ W/(m^2K)$

iii. Slope roof with 12mm cement plaster, 100mm RCC slab, 19mm screeding, 6mm cement tile

For cement plaster, $k_1 = 0.721$ W/(mK), $L_1 = 0.012$ m, $\therefore R_1 = \frac{L_1}{k_1} = 0.0166\ (m^2K)$

For RCC slab, $k_2 = 1.58$ W/(mK), $L_2 = 0.100$ m, $\therefore R_2 = \frac{L_2}{k_2} = 0.063\ (m^2K)/W$

For screeding, $k_3 = 0.41$ W/(mK), $L_3 = 0.019$ m, $\therefore R = \frac{L_3}{k_3} = 0.0463\ (m^2K)/W$

For cement til e, $k_4 = 0.100$ W/(mK), $L_4 = 0.006$ m, $\therefore R = \frac{L_4}{k_4} = 0.0635\ (m^2K)/W$

We have,

$$\frac{1}{f_i} = \frac{1}{9.36} = 0.1068 \text{ and } \frac{1}{f_o} = \frac{1}{19.86} = 0.0504$$

$$\therefore R_T = \frac{1}{f_o} + \frac{1}{f_i} + R_1 + R_2 + R_3 + R_4 = 0.347\ (m^2K)/W$$

$$\Rightarrow U = \frac{1}{R_T} = 2.882\ W/(m^2K)$$

iv. Flat roof with 100mm RCC slab, 19mm cement screeding, 12mm cement plaster both side

For cement plaster, $k_1 = k_2 = 0.721$ W/(mK), $L_1 = L_2 = 0.012$ m, $\therefore R_1 = R_2 = \frac{L_1}{k_1} = \frac{L_2}{k_2} = 0.0166\ (m^2K)$

For RCC slab, $k_3 = 1.58$ W/(mK), $L_3 = 0.100$ m, $\therefore R_3 = \frac{L_3}{k_3} = 0.063\ (m^2K)/W$

For screeding, $k_4 = 0.41$ W/(mK), $L_4 = 0.019$ m, $\therefore R = \frac{L_4}{k_4} = 0.0463\ (m^2K)/W$

We have,

$$\frac{1}{f_i} = \frac{1}{9.36} = 0.1068 \text{ and } \frac{1}{f_o} = \frac{1}{19.86} = 0.0504$$

$$\therefore R_T = \frac{1}{f_o} + \frac{1}{f_i} + R_1 + R_2 + R_3 + R_4 = 0.283\ (m^2K)/W$$

$$\Rightarrow U = \frac{1}{R_T} = 3.5\ W/(m^2K)$$

4. Performance Evaluation of Building

Various mathematical techniques have been developed for evaluation of performance of buildings. For this study, the inside temperature of the house is assumed to be maintained at a constant dry bulb temperature of 24°C. In such scenario, the hourly heat gain/loss is calculated using either CLTD (Cooling Load Temperature Difference Method) or Transfer Function Methods. Both methods have been used according to the availability of CLTD values and Transfer Function Coefficients that is similar to the building elements commonly constructed in Kathmandu. For these value ASHRAE Handbooks have been referred. Due to lack of matching values of CLTD for the typical roof of Rajbhandari house, roof with similar thermal behavior has been taken for the study.

4.1 Cooling Load Temperature Difference (CLTD) Method

It is the procedure to calculate cooling load on an hourly basis.

4.2 Basic CLTD cooling load for exterior surfaces:

q= UA (CLTD) where,
q= cooling load, W
U= coefficient of heat transfer, (W/m^2K)
A= area of surface, m^2
CLTD= cooling load temperature difference

The following sections show the graphs from the calculated values of heat flow (Q) from perimeter walls and roof section for different orientations or surfaces for 24 hours. It shows the heat flow for the months June and December using CLTD Method.

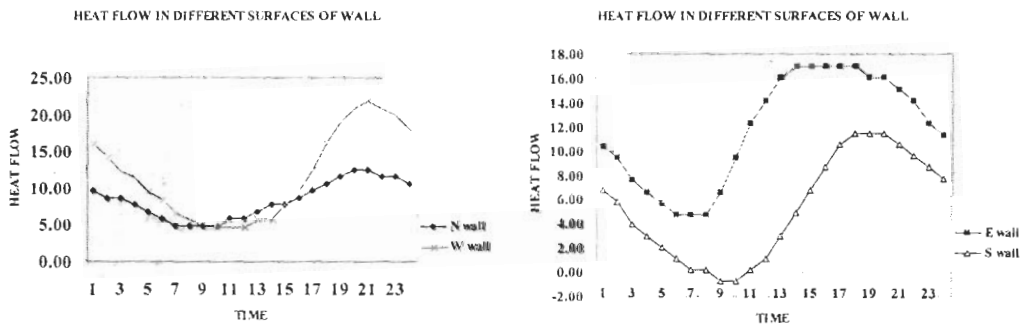

Fig: Heat Flow (Q) from perimeter wall on North (N), West (W), East (E) and South(S) facing walls for 24 hours in June

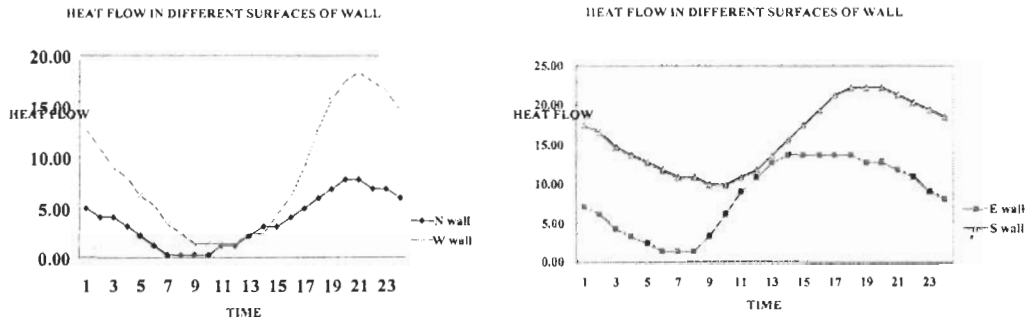

Fig: Heat Flow (Q) from perimeter wall on North (N), West (W), East (E) and South(S) facing walls for 24 hours in December

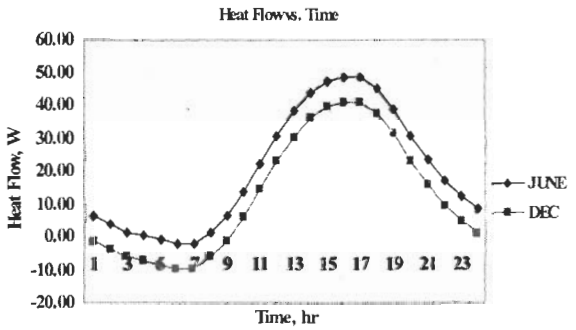

Fig: Graph showing Heat Flow (Q) on Roof for the months June and December (roof with a 13mm stone tile, 10mm felt and membrane, 100mm light weight concrete in 24 hours which has the similar thermal behavior of the Rajbhandari house)

4.3 Hour by hour load calculation using Transfer Function Method

This method is particularly well suited with the computer programme, so for this study FORTRAN has been used. This approach uses solar temperature to represent outdoor conditions, and constant indoor air temperature is assumed to be 24°C. Furthermore, both indoor and outdoor surface heat transfer coefficients are assumed constant over time. Thus, the heat gain through a wall or roof is given by:

$$q_{e\theta} = A\left[\sum_{n=0} b_n\left(t_{e,\theta-n\delta}\right) - \sum_{n=1} d_n\left[\left(q_{e,\theta-n\delta}\right)/A\right] - t_{rc}\sum_{n=0} c_n\right]$$

where,

$q_{e\theta}$ = heat gain through wall or roof

A = indoor surface area of a wall or roof, m^2

θ = time, hr

δ = time interval, hr

n = summation index

$t_{e,\theta-n\delta}$ = sol - air temperature at time $\theta - n\delta$ °C

t_{rc} = constant indoor temperature, ° C

b_n, c_n, d_n = conduction transfer function coefficients

For the calculation of heat flow using transfer function coefficients for different constructions, approximate value can be obtained by selecting as per ASHRAE handbook nearly the same as the roof or wall under consideration.

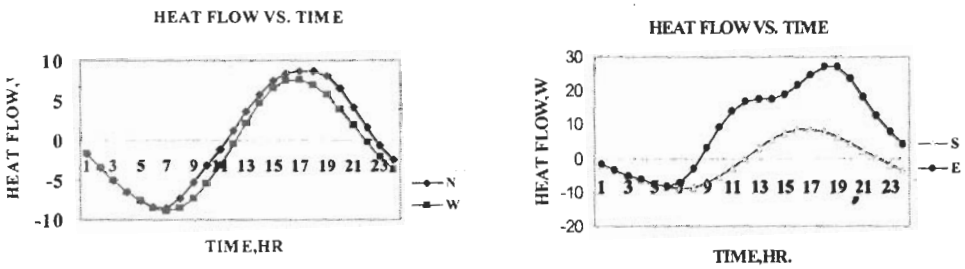

Fig: Graph showing Heat Flow from wall on different surfaces- North, West, East and South for the month June and December

5. Results:

- On the basis of the procedure and methodology described, we can draw the conclusion that the wall and roof sections of Rajbhandari House seems to perform well in context of heat transfer inside the building when calculated for 24 hours.
- From the calculations, building materials used in walls and roof of Rajbhandari House have lower U- value than that of Civil Homes.
- Graphs of Hourly Heat Flow Pattern for 24 hours also show that the traditional building has favorable thermal behavior and seems to perform well,whereas the graphs of Civil Homes show that wall section loses heat when the temperature is below comfort range (assumed comfort temperature is 24°C).

So, the wall and roof sections used in traditional type of buildings seem to have a better thermal performance than in the building elements with modern materials.

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DESIGN AND IMPLEMENTATION OF CROSS-LAYER PROTOCOL IN WIRELESS NETWORKS

Reny Bajracharya[1]
Riwaj Sapkota[2]

Abstract

The explosive growth in communication networks has expanded the purpose of modern telecommunication. Services such as voice communication along with huge data service, internet connection and other facilities inbuilt will all contribute to modern day composite structures. This paper deals with design and implementation of Cross layer protocols which will long serve the purpose especially in ad hoc networks and help understand the construction seamless multi hop networks. Highlight of the paper is the representative (and not exhaustive) description of violence of traditional layered protocols. Further, the possible challenges and the choices to be made during designing62 the protocol have been emphasized.

Keywords: Cross layer, Protocol, Architectural Violence, Layer Interaction

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1. Introduction

Advancement in wireless networks and the ever increasing demand to offer real time applications, merger of data and limitation of resources has led to the development of several communication protocols. Traditional layered protocols such as OSI and TCP/IP have long proved to be the basis and served as strong reference models for an overwhelming number of new protocols for decades. The protocols, thus designed, are rated and implemented based on their reliability, robustness, scarce resource utilization and Quality of Service (QoS). However, the inflexibility and sub optimality of these paradigms owing to modern day heterogeneous traffic demand has prompted researchers to digress from layered protocol. The recent interest has been in shifting from layered protocols to cross layer protocol design—the violation of layered protocol architecture—an attempt to fulfill the performance advancement innovation.

The architecture of layered protocols involves independent and transparent layers above and below each one such that modification in the layer without affecting the other layers is possible. The only requirement is that there should be a compatible interface between the layers [3]. The basic design consideration in cross layer protocol regarding the interface compatibility and architecture division are almost same as of the layered architecture. The only difference is that the layers are not independent of each other [11]. This means a change in any one layer can affect other related layers such that the strict layered boundaries are faded off. More over the direction of information flow service can be from and to any layers.

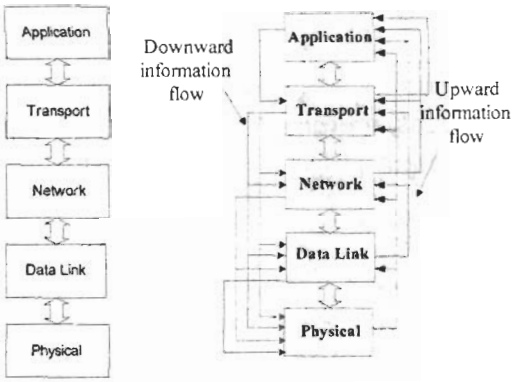


Figure1.1: Basic Communication Protocol Concept [12]

Although layer-independence (modularity) achieved through traditional methods serves as an organizing principle, layering is cumbersome at modern times where strict end-to-end model of the original internet architecture is not followed resulting in an inefficient implementation of a protocol suite. Cross layer protocols with unique advantages over layered protocols in terms of user mobility, frequent link failure, limited link capacity, limited battery and computational resources of mobile devices along with the diverse QoS provide an appropriate approach to solve the problem [8].

2.Design Considerations and Implementation

Researchers have proposed Cross layer protocol design based on *architectural violation* and *layer interactions* [11].

2.1 Architectural Violence

Two assumptions are made before describing this cross layer design: first the cross layer design is representative and not exhaustive, secondly, the reference architecture taken is assumed to be the five layer model i.e. the application layer, transport layer, network layer data link layer and physical layer [11].

Architecture can be violated in four different ways namely creating new interfaces, merging the layers, design coupling without new interface and vertical calibration [11].

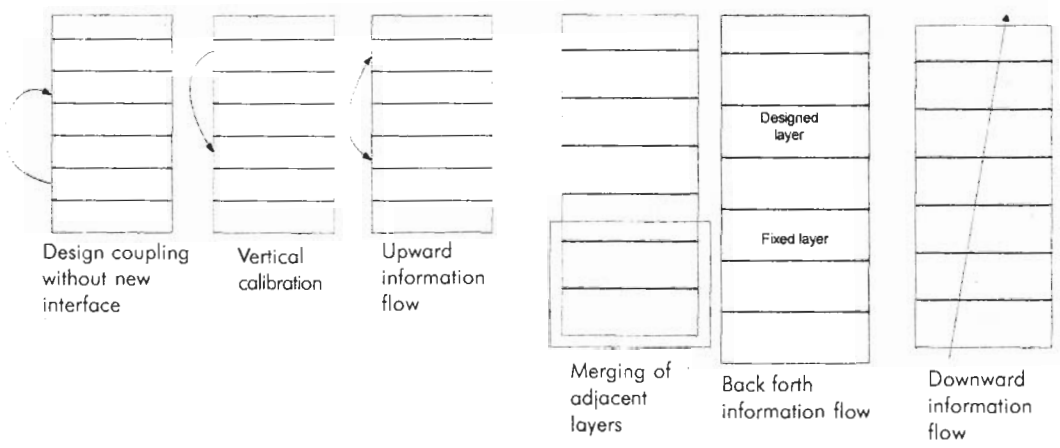


Figure 2.1: Cross Layer Design Based on Architectural Violence [11]

Design of new interfaces is determined by the direction of information flow within the layers viz. upward information flow, downward information flow and back and forth information flow. Each name suggests the direction of information flow. For example, upward information flow means the upper layer will use some information from lower layer. All these violence are done at run time.

One way of implementing upward information flow is by designing Transmission Control Protocol (TCP) with congestion notification in the header, where congestion notification is obtained from network layer reliable end to end transmission and congestion control. The ECN (Explicit Congestion Notification) in the header of the TCP is set to value zero by the source. If router indicates congestion

in the network, it changes the value to one. This helps the TCP in transport layer to differentiate between loss due to congestion and the loss due to wireless channel error. ECN mechanism provides a means of explicitly indicating congestion [9].

"Some cross layer design proposal rely on setting parameters on the lower layer of the stack at run time using a direct interface from some higher layer" [11], also termed as downward information flow.

Inter layer communication proposed by adding Hint and Notification (HAN) to the layered architecture can be taken as an example of downward information flow. The limited radio spectrum resource available is used efficiently by reducing the unnecessary delay and retransmission in the link layer. By getting hints from network layers, link layers can use spectrum conservative mechanisms to a greater extent [5]. HAN is placed in the header of network layer which is defined by surrounding layers using IP option and ICMP messages. Hint includes boundary information about the data packets like acceptable error rate and delay. By getting this information the link layer can choose the suitable modulation scheme and error correction mechanisms which can help to avoid packet loss, delay and react to short term variations.

Notification is the mechanism to provide information from lower layer to upper layer. This is used in two aspects: link action notification and link status notification. Link action notification handles the misinterpreted loss and temporary disconnection problem caused due to congestion responsive application whereas link status notification handles the problem caused by real time application like unknown link property [5].

"When two layers performing different tasks collaborate with each other at run time, an iterative loop between the two layers is formed with information flowing back and forth". For instant, the proposed cross layer design in [2] is based on 'Network assisted Diversity Multiple Access (NDMA)' to avoid the data collision by joint MAC-PHY layer solution. The concept of NDMA is highly influenced by spread spectrum and receiver antenna diversity. The basic idea is to collaborate physical layer with the MAC layer using signal processing technique to solve the collision resolution problem. Collaboration of physical layer helps in recovering packets from collision.

When designers resort to form a 'super layer' by merging two or more adjacent layers together, it is called merging of adjacent layers. The merger output of super layer is expected to be the service provided by the combination of two merged layers. The super layer can thus be interfaced with the other layers in the architecture stack. But this approach possibly increases the design complexity

and thus is not recommended and implemented yet [11].

Design coupling without new interface involves coupling two or more layers at design time without creating any extra interfaces for information-sharing at run-time [11].

The attempt to bring together the modeling of medium access control for ad hoc networks with different smart antenna technologies under a common framework and use it towards the design of unified centralized algorithms is an example of design coupling [4]. This can be achieved by effectively leveraging capabilities of smart antennas through some changes in MAC layer. A unified MAC algorithm implemented with the PHY layer capabilities with different smart antenna under various network topologies serves this purpose.

Unified MAC framework, a centralized algorithm, maximizes the utilization of network subject in terms of transmission and confirms fairness in the model. The proposed solution consists of three components: generation of flow contention graph, coloring the link and scheduling the link. Along with generation of contention graph, it is also required to determine the entire contention region i.e. the maximal group in the graph and arrival at the minimum group cover. The second step is coloring the links. This is done to identify the bottleneck links and schedule them properly ensuring the fairness. After determining the maximal clique and coloring them the third component schedules the link within the slots satisfying the constraints and maintaining fairness of the model. The performance trade off between switched beam array and adaptive array in terms of range extension and rate increase in different network condition is shown in following figures.

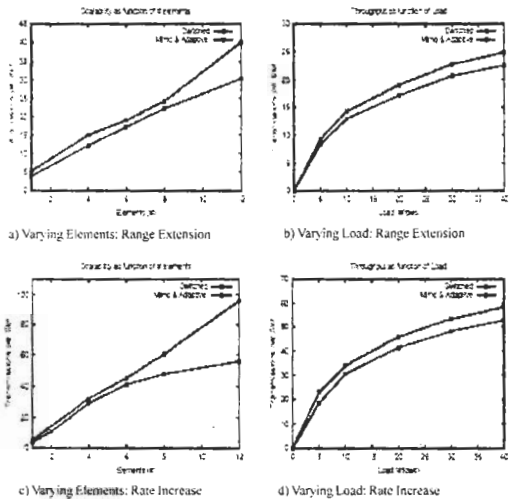


Figure 2.2: Performance of Switched Beam and Rate Adaptive Array for Range Extension and Rate Increase in LOS [4]

Special care should be taken while creating new interface because a change in technology at one layer will need to be complemented by corresponding changes to other layers.

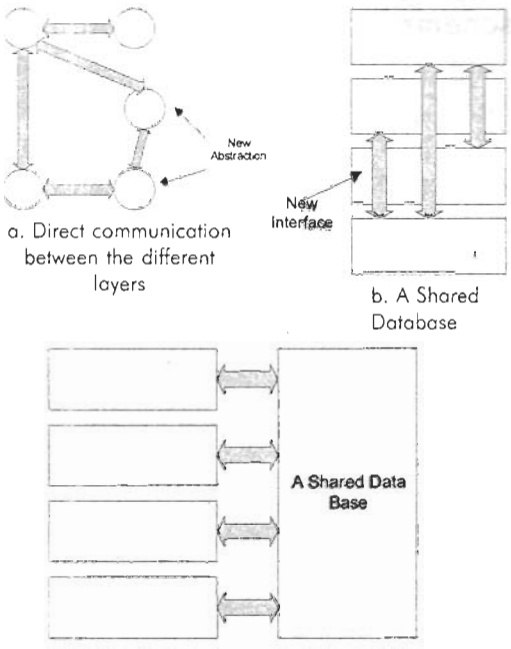
The final cross-layer design proposal refers to vertical calibrating parameters that cover across the layers. In this design, the application performance is a function of

parameters at all layer level such that the joint modification can achieve better performance. Vertical calibration if done in static manner, the settings of parameters can be done in design time for optimization of metric whereas if done in dynamic way the parameter adjustment is done at run time which makes the response of the protocol flexible to the channel variation [11].

The optimization of TCP performance can be done by increasing the power management and retransmission of data. Jointly tuning of power, forward error correction (FEC) and automatic repeat request (ARQ) can improve the TCP performance by reducing the link layer losses. This can be seen as vertical calibration of the layers i.e. performance of one layer is a function of parameters of other layers [1].

2.2 Layer Interactions

According to [11], cross layer protocol can also be designed based on the layer interactions. The layer interaction in cross layer is basically not with the adjacent layers but should violate the traditional way of interaction. Interaction between layers can be done by allowing layers to communicate directly, sharing a common database or designing a completely new abstraction.



a. Direct communication between the different layers

b. A Shared Database

c. Completely new abstraction

Figure 2.3: Cross Layer Design Based on Layer Interaction [11]

Allowing the direct communication between layers (adjacent or non adjacent) is the simplest way of information sharing between them. This means a significant performance improvement can be achieved just by implementing a few cross layer information exchange while keeping the layered architecture tractable [11].

This method is explained clearly in proposal [7] where a cross layer signaling is implemented to achieve significant performance gain. The proposed cross layer signaling is termed as 'Cross Layer Signaling Shortcuts (CLASS)' which is an *efficient, flexible and comprehensive*

scheme that allows direct communication between any two layers. Other features provided by CLASS are light weighted internal message format for internal signaling and standardized external message format for external signaling. The conceptual model of direct signaling between non neighboring layers can be referred in the figure.

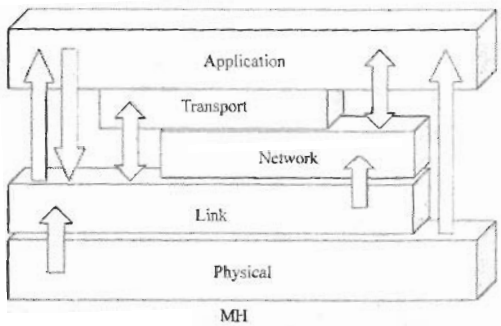


Figure 2.4: Concept Model of CLASS [7]

Sharing a common database is designed so that it can be accessed by all the layers in the protocol stack while satisfying the layer separation principle. The common database is like a new layer shared by all the layers providing the service of storage/ retrieval of information to all [11].

The "Mobile Man" cross layer architecture proposed in [6] is an example of shared database architecture. Mobile man is basically cross layer design for mobile ad hoc network (MANET). Mobile man presents a core component termed Network Status which is placed beside the normal layer allowing the access by each layer for data sharing. This approach aims to optimize overall network performance by increasing local interaction among protocols, decreasing remote communications and consequently saving network bandwidth.

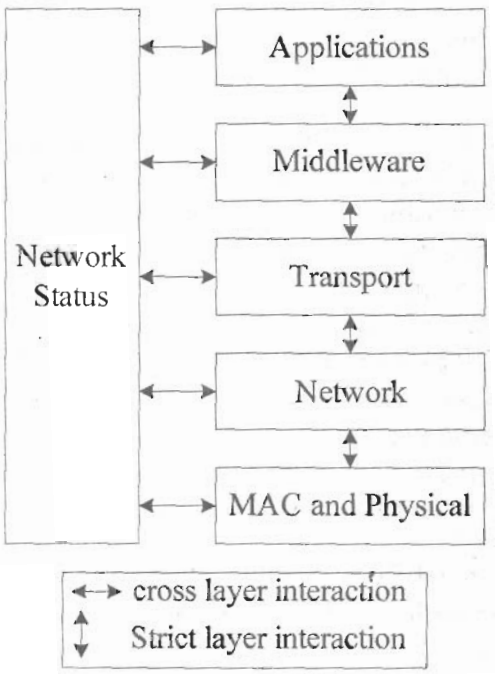


Figure 2.5: Mobile Man Architecture [6]

Implementing Mobile Man architecture in ad hoc networks provides benefits all network functions along with energy management. The performance advantages can also be achieved in terms of improving local and global adaptation to adapt the system to highly variable ad hoc network conditions. Reduced overhead avoids data duplication at different layers by collecting Network Status information.

Completely new abstractions present a new way to organize the protocols in heaps and not in stacks. In this concept the protocols are broken into smaller units called building blocks and the overall network behavior is described by the interactions between the different building blocks. These proposals are appealing as they allow good interactions between the building blocks and are flexible in designing and optimizing protocols [11].

3. Challenges in Cross layer Protocol Design

The advantages of cross-layer networking appear to be real, and will be increasingly important as wireless communication interfaces with internet backbone. Many works relating cross layer protocol design have been proposed and have successfully been implemented which have proved to provide performance gain and fulfill the QoS requirement. In spite of numerous studies in cross layer protocol design there still remain some open questions which are still not addressed like co existence of cross layer with one another, standardization of interfaces used for information exchange, role limits of physical layer and so on. All in all, it would be quite relevant to understand a few challenges in cross layer design as pointed in [9].

3.1. Multi user diversity gain

Multi user diversity gains can substantially improve wireless network throughput. However with different QoS limitations, growth of diversity gain in multi user environment is of great importance from a practical viewpoint. Designing a good algorithm which makes use of multi user diversity gain in the multi cell case would be of great interest.

3.2. Modeling network performance

Creating models that translate actual channel characteristics into useful models at the network layer targeting actual network field data will enable scheduling and traffic techniques to be developed accurately. Adaptive control of wireless networks, on a building-by-building basis, may also be useful to ensure proper scheduling and utilization of capacity as more access points and users are added in unlicensed spectrum.

3.3. Design for multi carrier systems

Most of the scheduling algorithms today for 3G wireless systems are developed for a single carrier system. While scheduling algorithms based on multi carrier schemes (OFDM) are expected for emerging WLANs and fourth generation wireless systems. Design of

scheduling algorithm with low complexity can be an interesting area to explore with.

4. Conclusion

There is no doubt that cross layer can bring significant change in network performance. One should be cautious while choosing the interacting layers as change in one layer will affect the whole architecture which may lead to communication break down. Since these interactions are some times not foreseen, insufficient care might lead to "law of unintended consequences" [10].

System dynamics, stability, robustness and timescale separation are some of the factors to be considered during cross layer design.

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