MOBILE AND COMPUTER COMMUNICATIONS THROUGH COLOUR SIGNALS – AN APPROACH NOTE

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Abstract: The objective of this paper is to discuss a methodology for achieving mobility through colour signals applicable for wireless networks. The colour is used as the address of the wireless nodes in the network and for carrying the signaling and the bearer traffic. The present day video systems that can generate millions of colours, in its electronic form have been utilized for setting up a wireless network, serving mobile stations or computers as its nodes. A specific colour level is assigned for a user as its address and for exchange of data. Theoretically, the number of users that can be served by such colour circle has no upper cap, because the possible colour combinations are virtually infinite. But it is constrained by the sampling frequency of the available video technologies. The paper provides a basic introduction of the technology and attempts to compare with the prevalent wireless technologies on various aspects. The technology finds application for Wireless Computer Networks, Closed User Networks and for Mobile Networks.

1 INTRODUCTION: THE COLOUR CIRCLE AND WIRELESS NODES

Isaac Newton said, “Indeed rays, properly expressed, are not coloured.”

Spectral power distributions (SPDs) exist in the physical world, but colour exists only in the eye and the brain. Colour is the perceptual result of light having wavelength from 400 to 700 nm that is incident upon the retina. The question is, whether the colour, generated by the electronic video systems and perceived by the human retina can be utilized to render individual / discrete identities to millions of network nodes which can eventually form a mobile or computer network.

The nodes of the wireless network for mobile or computer are represented as specific colour levels in the colour circle. A band of saturation level is spread across the colour vector, a sub-band of which is meant for signaling and the remaining for bearer traffic. For a mobile network, the coordinate of the Mobile Station in the colour circle is decided during provisioning. Similarly, for a computer network, the IP address (and subnet mask), of the computer or peripheral decides the position of the node in the colour space domain. Hence for a mobile or computer network, the MIN and the IP address (subnet mask) needs to be a function of the phase of the colour vector and the band of saturation level for transcoding voice and signaling.

MIN (E.212 NP) / MDN (E.164 NP) = f (Ø , S_B) for mobile network.

IP (Class A, B and C) = f (Ø, S_B) for computer network,
Where S_B => the band of saturation level allotted to the user for signaling and bearer data

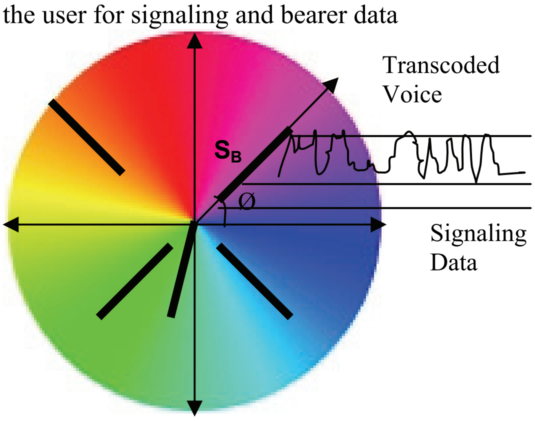

Figure 1: Space coordinate representation of the Wireless Nodes in the colour space domain.

Sanyal R. (2006).
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2 DESIGN BASIS OF A WIRELESS COMPUTER NETWORK BASED ON COLOUR SIGNALS

The basic architecture of a single MAC Colour Computer network (wireless) provides mobility within a large Location Area. However, it is also possible to actuate mobility across multiple MAC Networks.

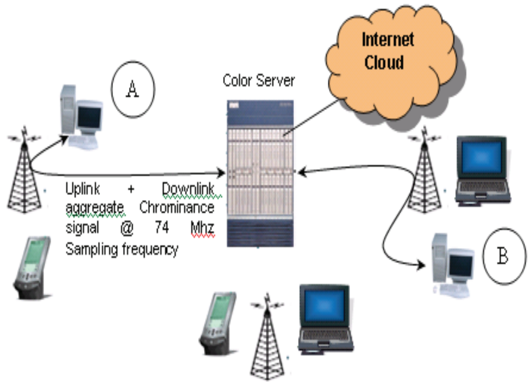

Figure 2: Architecture for Wireless Computer Network.

Node A Initiates to set up a wireless connection with Node B. It generates a colour train within the saturation band allotted for signaling (Pat. No. 188052, Govt of India, October 1995).

The signaling data contains the IP Address (Sub net mask information) of Node A and Node B. The video repeater, which acts as an access point, collects the information from various sources, aggregates as a common Chroma Signal and forwards it to the colour server. The colour server receives the colour signals from all the sources (the repeaters) and forms an aggregate chrominance signal for the downlink which is broadcast in the network area. The colour server (which is the heart of the network and actuates all the virtual routing functionalities), generates a colour train within the saturation band allotted for the Node B. The Node B acknowledges the connection request .The colour server sets up a semi permanent connection between Node A and B on the assigned Ø and S_B for Node A and Node B, respectively.

Using the HDTV 1080i technology , which has a colour sampling frequency of 74.25 Mhz (each colour sample corresponds to a bit) , and assuming that each wireless node enjoys a forward and reverse data rate of 2Mbps, the number of simultaneous users that can be accommodated in a single colour circle is 37. The deployment architecture can be the same followed in WLAN where each colour circle creates a Basic Service Set (BSS) and multiple BSSs form an Extended Service Set. The Colour server will essentially perform the functionality of a Distribution System (DS) which actuates intercommunication between multiple access points. The power requirement in the handset to achieve an uplink data rate of 2 Mbps depends on its distance with the access point. However, the access points are inexpensive dumb video repeaters which do not have any discrete address in the network . Setting up a colour hot spot will be cheaper and easier compared to the existing wireless access technologies. Also the number of the repeaters in the network area can be increased to minimize the power requirement of the wireless nodes.

2.1 Network Architecture of a Standalone PCS Wireless Network (Closed User Group and not Linked to External Legacy Networks)

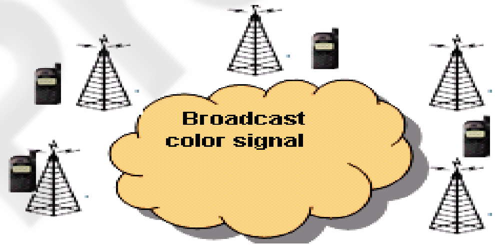

Figure 3: Network Architecture of PCS network.

The mobile station consists of the chrominance signal transmitter, which generates colour as a function of the dialed E.164 number. In a closed user environment with limited users, the numbering plan will be fairly simple. Hence the algorithm for generating the color as a function of the E.164 Number can be housed in the Mobile Stations. Assuming that we use the HDTV 1080i technology , and the digital vocoder transcodes the voice at a sampling frequency of 8 KHz , the number of users , that can communicate in a colour circle simultaneously in a given network on a single channel / carrier frequency = 74.25 x 10^3 / 8 = 9280 (HDTV 1080i specifications). This however does not take into account the interference factors , which will lessen the spectral efficiency to some extent.

2.1.1 Functional Specification of the Mobile Station

The Mobile Station will be capable for setting up a forward and reverse channel with the network for voice and signaling. It consists of the following functional blocks (Sanyal, Patent App.No. 0163/MUM/2006 , Govt. of India). The system components for supporting the supplementary services are not included.

- NAM & SIM Holder Interface – Number Assignment module which stores all the MS related parameters , like MIN/IMSI , MDN , Channel Frequency (UHF or VHF)
- Colour Generator and transmitter: Mainly used for making an outgoing call and to enable full duplex communication while in a call.
  - E.164 Number to Hue and saturation level converter for generation of the colour as a function of the B Party Number (Dialed Number)
  - Video Encoder
  - Phase shifter
  - Video UHF/VHF Transmitter
- Colour Receiver
  - Video Transreceiver
  - Phase detector
- Logic module : to invoke and respond to different signaling messages and accordingly decide to make or break the speech circuit.
- Audio Unit
  - Audio PreAmp & AMP
  - Audio to RGB transcoder and vice versa
  - AM Bandpass filter
- Keyboard encoder
- Display Unit : LCD display unit
- Power supply Unit

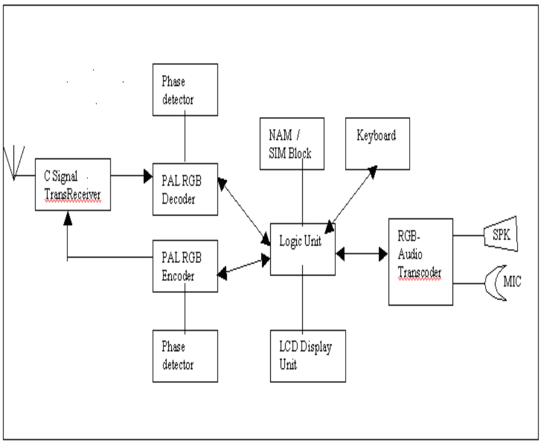

Figure 4: Block diagram of Keyboard encoder.

When a number is dialed, the subcarrier frequency is passed through an amplitude modulator (to actuate the saturation level) and is phase shifted (to form the hue) by a phase shifter to synthesize the desired C signal which is a function of the dialed number. The amplitude and the phase are determined by a logic unit (as shown in the diagram in Fig. 4) which is interfaced to the keyboard generator (Patent App.No. 0163/MUM/2006, Govt. of India, February 2006).

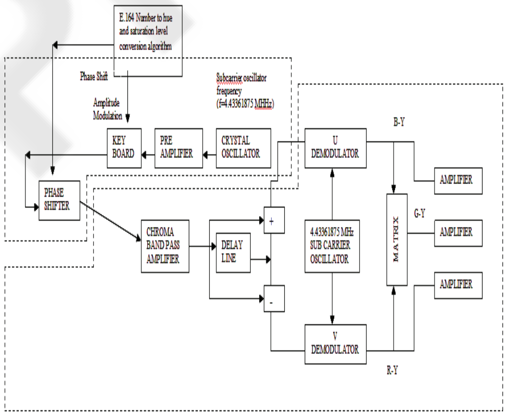

Figure 5: Keyboard Encoder for PCS Mobile Station.

2.2 Deployment Architecture for a Mobile Network

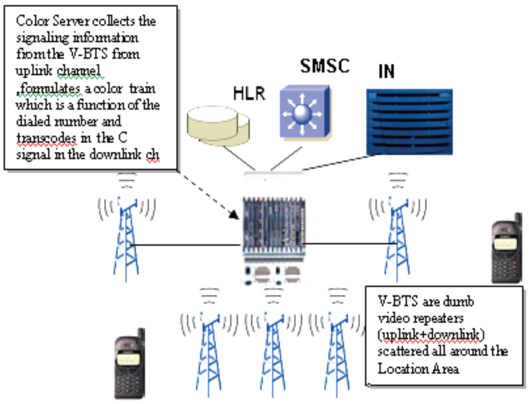

Figure 6: Mobile Network on Colour Signals.

Each Color Circle pertains to a single Location area and not subdivided into multiple orthogonal cells, as is present in the existing technologies like GSM or CDMA . The BTS is replaced by Video Transreceivers (termed as V-BTS) placed all over the network coverage area which can establish an uplink and downlink channel in UHF / VHF with the handsets (Sanyal, Patent App. No. 0163/MUM/2006, Govt. of India). The chrominance signal transmitted from the V- BTS is primarily a broadcast signal containing colour information , sampled at a specific frequency (for HDTV , the sampling frequency if 74.25 Mhz) for all its users in a given network coverage area. Each handset after receiving the chrominance signal demodulates it and filters out the colour signal (in terms of R – G – B Levels) pertaining to the specific hue and the band of the saturation level in digitized form. Within the specific band of the saturation level allotted for the subscriber , say Band A (ranges 10% to 35 %) , a specific sublevel say Band A1 carries the signaling information (for paging , Alert with Info , etc) and the Band A2 , carries the digitized voice information. The heart of the network is a colour server which processes all the colour information. The colour server interoperates with the MS through the V-BTS / V-BSC and exchanges the SS7 signaling information with the core network accordingly. The speech circuit between the A and the B party is established over the band of saturation level tied up with the colour level that has been assigned for both the parties.
The functional specification of the mobile station is the same as that show for the CUG PCS network, except for the fact that the Keyboard encoder does not need to hold the algorithm which ports the dialed E.164 number to color generator. This function instead exists in the colour server .
The primary functions of the colour server are the following.

1. Performs all the colour signal processing for the access network
2. Formulates the colour train which is a function of the dialed E.164 mobile number (of the same serving market).
3. Performs the Signaling operations (on SS7) with the core network
4. Interoperates with the V-BTS/V-BSC for the air interface related operations.
5. Interfaces with the Legacy Networks (on associated mode of signaling and PCM Voice trunks on F Links and on A links on quasi associated mode).
6. Call Data Record generation for Mediation / Billing
7. Call routing for the legacy network
8. SSP Functionality for Intelligent network operations
9. Supports Supplementary Services

2.2.1 Advantages

- Eliminates the need of complex time and space switching matrix present in modern days mobile networks.
- No need of frequency re-use , needs lesser number of channel frequencies compared to GSM or CDMA.
- No need of complex planning of macro / micro / pico cells. Coverage area can be split up into broader areas and scattered with Video Repeaters .
- Instead of increasing the number of cells to increase coverage, as in GSM/CDMA , it is only required to add more inexpensive video repeaters to increase the size network area , until the maximum number of subscribers that can be catered by a single color server is not reached. Power Requirement of the Mobile Station depends on the number of repeaters placed in the coverage area. No power misuse due to increased signaling, as in GSM or CDMA.
- Signaling overhead is much less , resulting in a cheaper network. No complex handoff mechanisms required (like soft handoff or hard handoffs) or other operations related to mobility management.

- Reduction in the backhaul / transport. The calls within the same V-BTS can be processed locally and need not be taken towards the colour server .
- Faster deployment, low maintenance cost of the network, less manpower required for operations.
- Can be built upon the existing television /cable TV network . Satellite transponders meant for video communication can also be used for voice and data.

The following study shows a comparison of the proposed technology for mobile networks and GSM in terms of the network capacity and spectral efficiency.

2.3 Capacity Calculation

In GSM, the radio spectrum in the bands 890-915 MHz for the uplink (mobile station to base station) and 935-960 MHz for the downlink has been reserved in Europe for mobile networks. The uplink and downlink band , each of 25 Mhz , is divided in 124 channels. Each of the 124 channels can support 8 separate connections with one time-slot per connection . Theoretical limit of 124 channels x 8 connections per channel = 992 connections per cell. But, many frequencies in any particular cell are not used to avoid conflicts with neighbors, resulting in much reduced support of simultaneous calls.

Capacity in terms of Call Connections per Mhz of Bandwidth in GSM = 992 / 25 = 40 or lesser.

Span of a cell in GSM = few Kilometers radius. Size is constrained by technology.
The 1080i HDTV theoretically requires a 37 MHz video bandwidth. Sample rate for 1080i HDTV is 74.25 Mhz. The subscriber's speech will be transcoded through the VOIP codec, which requires a sampling frequency of 8khz (data taken for VOIP Codec specification). Simultaneous calls supported = 74.25Mhz / 8 KHz = 9280.

Capacity in terms of users per Mhz of Bandwidth = 9280 / 37 = 251.
Span of a cell = An entire coverage area can be made up of a single cell, and size of the cell is not constrained by technology , the determining factor being the call attempts that is required to be supported.

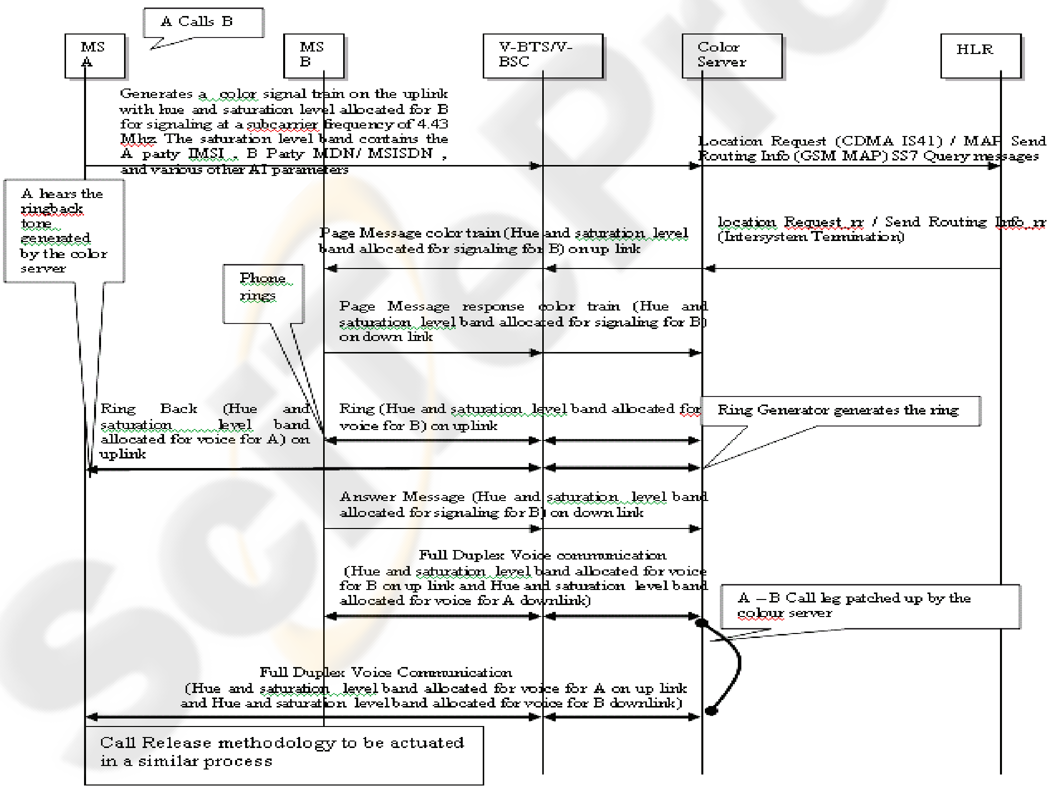

Figure 7: Call flow for a call initiated by the A party towards the B party is shown below (ANSI 41 – D Specification / ITU-T MAP 2 Specification).

3 EXPERIMENTAL SETUP FOR VOICE COMMUNICATION ON COLOUR SIGNALS

The experiment was performed based on the primary colours (Red , Green , Blue) .With the setup, three VHF colour transmitters ,each capable of transmitting red , green and blue colour levels respectively were transmitting modulated Saturation level (voice transcoded to colour with the aid of a suitable driver) on these basic colour levels (RGB) .The receiver decodes the three different voice signals transmitted on the three basic colour levels and feeds the signals to three different speaker outputs. The audio output in each channel was distinct with no distortion.
The phase and the voltage of the basic color signal (RGB) are determined by the following equations.
The equation of the illuminance signal (Y) is

$Y = 0.30\,R + 0.59\,G + 0.11\,B$
Hence $R\text{-}Y = 0.7R - 0.59G - 0.11B$
$R - Y$ is maximum when G and B are 0.
Similarly , $B\text{-}Y = 0.89B - 0.59G - 0.3\,R$
B-Y is maximum when G and R are 0.

When there was no audio input , and hence no signal pertaining to the Green and Blue section , and when a constant voltage output of 1 volt was obtained from Red color output (in the chroma section of the video transmitter) , the Magnitude of the composite chroma signal is $|C| = \sqrt{(R\text{-}Y)^2 + (B\text{-}Y)^2} = 0.7\text{v}$
The phase angle of the color vector , in that situation which governs the hue is

$$\Phi = \tan^{-1} (R\text{-}Y) / (B\text{-}Y)$$
$$= -\ 66.80^{O}$$

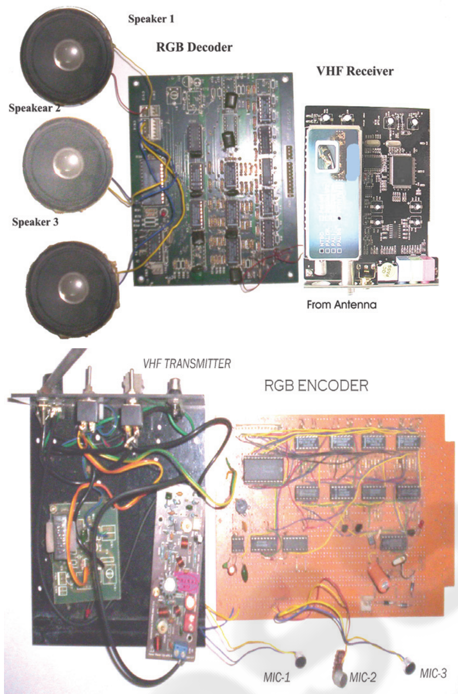

Figure 8: Triple Audio Receiver and Transmitter on Basic Colour Signals (RGB) as carrier signals and built upon PAL VHF Transmitter and Receiver.

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ANSI 41 – D Specification / ITU-T MAP 2 Specification
HDTV 1080i Specification