# Outdoor and Indoor Applications for Broadband Local Loop with Fibre supported mm-wave Radio Systems.

Michel Goloubkoff, Elisabeth Pénard, Daniel Tanguy, Pierre Legaud
France Telecom / CNET - Lannion
Dean Mathoorasing, Fabrice Devaux, Christophe Minot
France Telecom / CNET - Bagneux

## Abstract

Radio over fiber is emerging as an attractive option for the delivery of broadband services. Two outdoor systems, in " FRANS ", an ACTS european project, will demonstrate the integration of bilateral point/multipoint mm-wave radio system over a Passive Optical Network ( PON) system and over an Hybrid Fiber Coax ( HFC ) system. These hybrid approaches can suit local access network operators future needs. For indoor systems, Radio over Fiber introduces restricted mobility. Thank to expected low cost transducers, bit rates of few tens of MBit/s have been demonstrated for Residential Broadband Applications.

## Introduction

The concept of hooking microwave terminals on optical fiber transport or transport of remote radio transmitter/ receiver is well known [1].

For broadband applications the concept has to progress towards a deeper integration of radio inside fiber optic system, allowing management system to integrate as much as possible the optical and/or radio parts. Seamless delivery of broadband services up to the terminal, independently of physical layer, is now the main objective and has to be demonstrated.

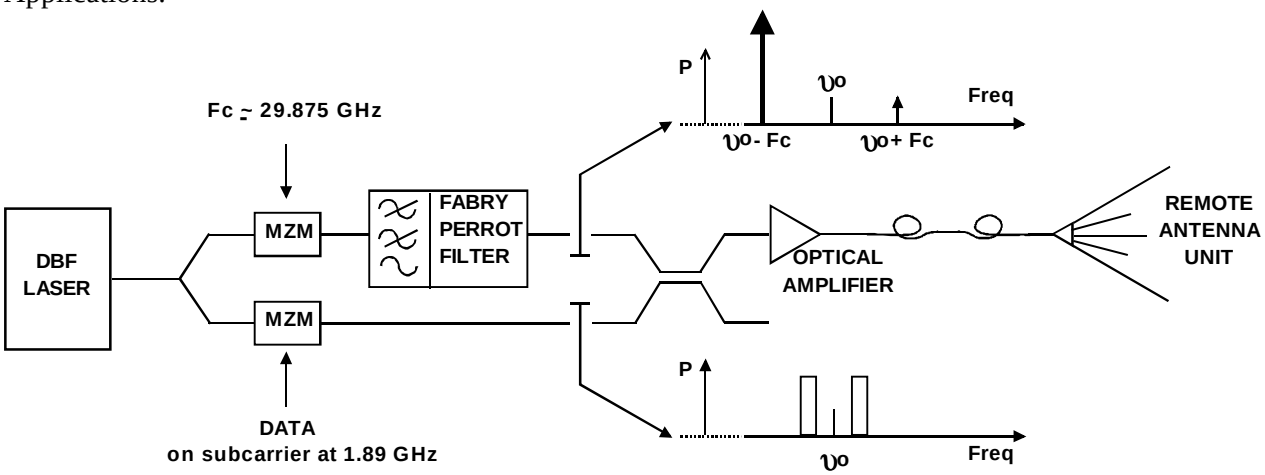


Fig 1 - Solution retained in FRANS project for data and millimetric carrier injection on fiber

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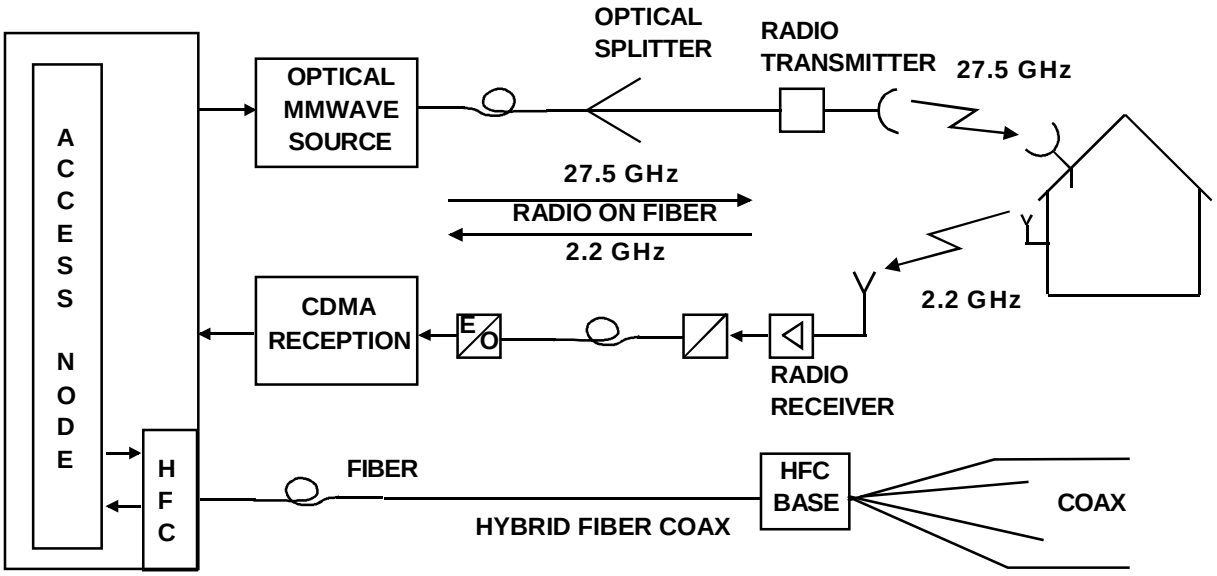


Fig 2 - Radio over Hybrid Fiber Coax system

## " FRANS " for OUTDOOR ACCESS.

This project " **F**ibre **R**adio **A**TM **N**etwork and **S**ervices" [2] is included in European ACTS Program as part of more advanced Integrated Broadband Communication Network ( IBC). FRANS deals with optical/mm-wave techniques for radio on fiber and will offer conclusions supported by two demonstrators

In both demonstrators, the mm-waves are generated by coherent mixing of two optical signals on a photodiode. This technical solution has been introduced in MODAL project by partners of previous RACE II fundings by European Community [3]. Block diagram is presented in fig 1. The optical carrier is splitted in two. The millimetric carrier and the data, on a low frequency subcarrier, drives two Mach-Zender modulators . An optical filter suppresses the upper optical band. Working at 1.5µm, it is important to avoid cancellations resulting of chromatic dispersion of classical G652 optical fiber. Then both optical signals are combined again. Other techniques are possible [4][5].

**Demonstrator 1 - Radio over HFC.- Fig 2**

The first demonstrator managed by Alcatel-SEL will offer 155 Mbit/s as a final drop ( radio replaces coax ) for an HFC local access network architecture.( Table 1)

| FRANS | Demonstrator 1 - Alcatel |
|---|---|
| Architecture | HFC |
| Capacity | 4x34 Mbit/s |
| DOWNLINK<br>Freq. band<br>Channel code<br>Modulation | 4 carriers at 34 Mbit/s<br>27.5-28 GHz<br>yes<br>QPSK |
| UPLINK<br>Freq.band<br>Bit/rate<br>Modulation | CDMA<br>2.2 GHz<br>2 Mbit/s<br>BPSK |
| Cell area | 500 meters |
| Main features | Reuse of DVB equipments<br>Both coax and radio |
| Services | Asynchronous |

Table 1 - Main features of radio over HFC

**Demonstrator 2 - Radio over PON - Fig 3.**

For CNET and associated partners, the demonstrator is a point/multipoint radio system merged as far as possible over a fixed optical fiber network FTTH ( Fiber to the Home ) with a PON ( Passive Optical Architecture) architecture. [6].

An existing PON system, at CNET labs, offering diffusion downstream at 622 Mbit/s and TDMA upstream at 40 Mbit/s is to be matched to radio at 28 Ghz with the most reused parts of PON equipment and management software. Radio is part of OLT ( Optical Line Termination) and transported by optical fiber to the remote antenna unit. (Table 2 )

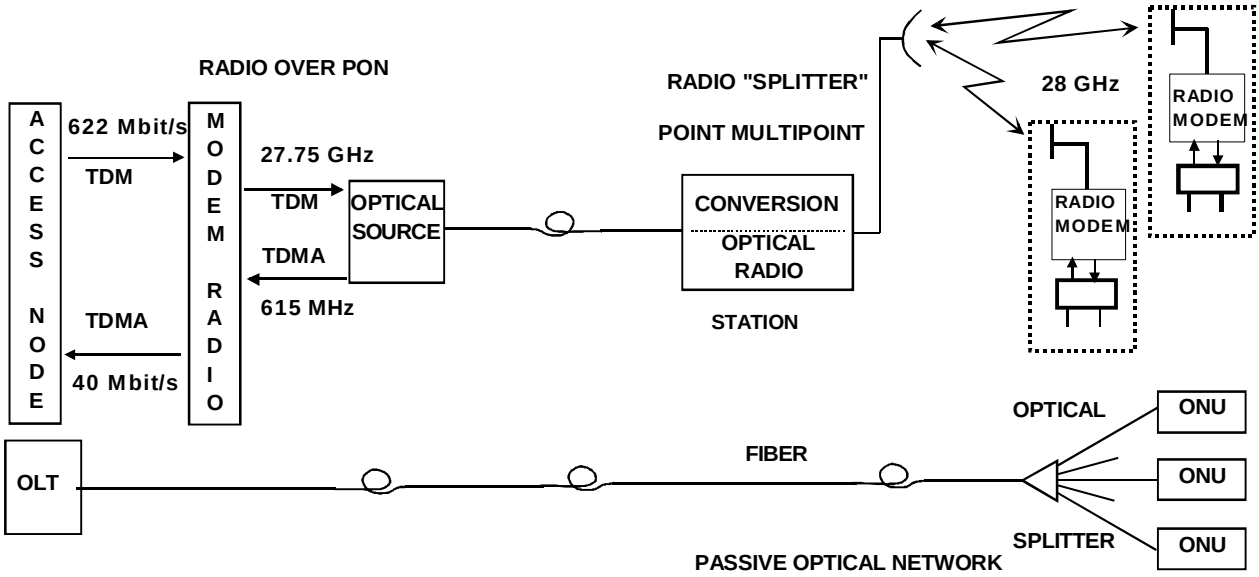


Fig 3 - Radio over Passive Optical Network

| | |
|---|---|
| FRANS | Demonstrator 2 - CNET |
| Architecture | Passive Optical Network |
| Downstream Capacity | 622 Mbit/s |
| DOWNLINK<br>Freq. band<br>Channel code<br>Modulation | TDM 622 Mbit/s- 1 carrier<br>27.75 - 28 GHz<br>yes<br>16QAM |
| UPLINK<br>Freq.band<br>Bit/rate<br>Modulation | TDMA<br>29.2 - 29.32 GHz<br>40 Mbit/s<br>2FSK |
| Cell area | 500 meters |
| Main features | Seamless optical/radio<br>Reuse of all functions of PON in TDM and TDMA management |
| Services | Both Synchronous and Asynchronous. |

Table 2 - Main features of Radio over PON

## BROADBAND INDOOR ACCESS

To supply radio extension to broadband services a alternative technique based on a special InP device has been investigated. Classical solution can be based on HBT as detector and amplifier. This solution is based on InP superlattice diode with negative resistance depending on illumination and working as an optically locked oscillator. [7][8].

First results at 38 and 60 GHz give encouraging results for modulation rates around 25 to 50 Mbit/s. Due to locked oscillator mode of operation only PSK or FSK modulation are feasible.

For the first time optical synchronisation of superlattice oscillators is reported with such large bandwith. An important work is necessary to improve optical parameters of the diode, and millimetric parameters of the oscillator to optimise the bandwith of the locking directly related to useful bit rate. When optimised, this dual component associated with integrated antenna and a low cost package will be really competitive.

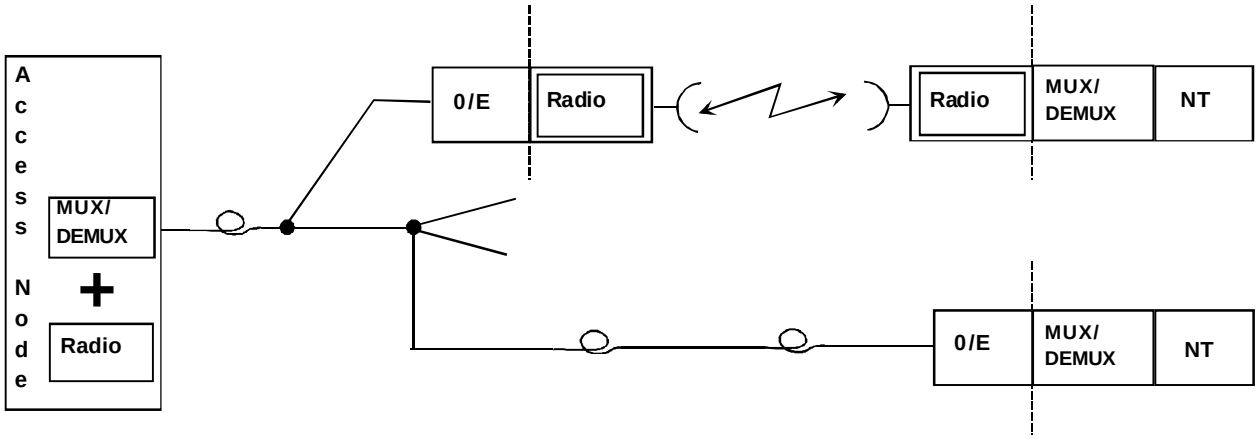


Fig 4 - A double medium radio and fiber for access network.

## Conclusion

If transducers are the key functions of optic/radio systems, a global reflexion is to be done to include at the early stage of optical systems definition for local access and broadband services. The integration of radio equipments has to be as close as possible of the operator facilities (local exchange) and the management of both physical layers radio and optic must be as similar as possible to offer easier alternative or migration from radio to a more definitive connection by optical fiber as shown in fig 4.

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