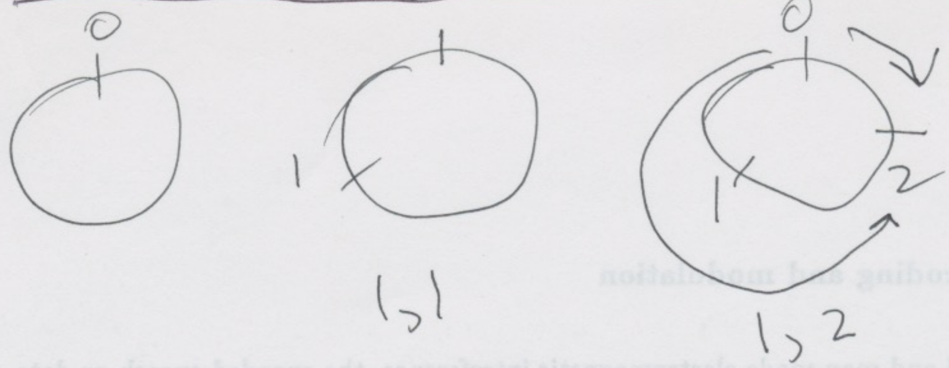
PARA-FIBONACCI SEQ ETC

Bud l

A45
A3603
A19586
A19594
A35336 ff
A2635 1,5
A201

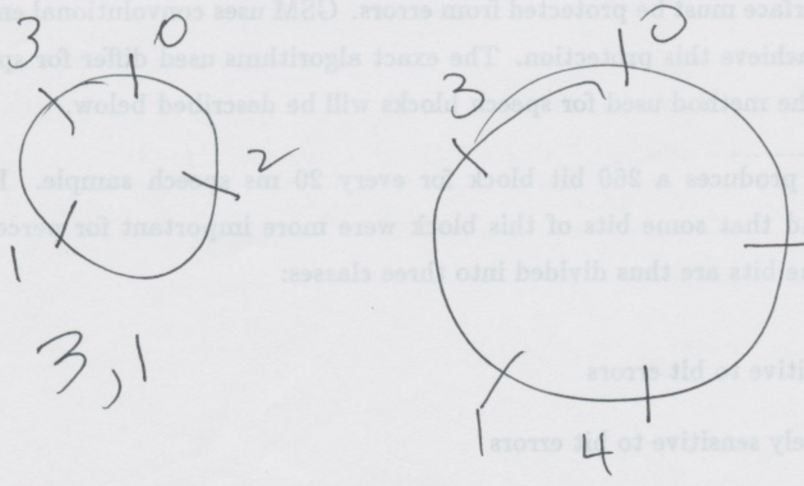



## Channel coding and modulation

Because of natural and man-made electromagnetic interference, the encoded speech or data signal transmitted over the radio interface must be protected from errors. GSM uses convolutional encoding and block interleaving to achieve this protection. The exact algorithms used differ for speech and for different data rates. The method used for speech blocks will be described below.

[n c]

~~perimeter~~ perimeter




Recall that the speech codec produces a 260 bit block for every 20 ms speech sample. From subjective testing, it was found that some bits of this block were more important for perceived speech quality than others. The bits are thus divided into three classes:

**Class Ia** 50 bits — most sensitive to bit errors

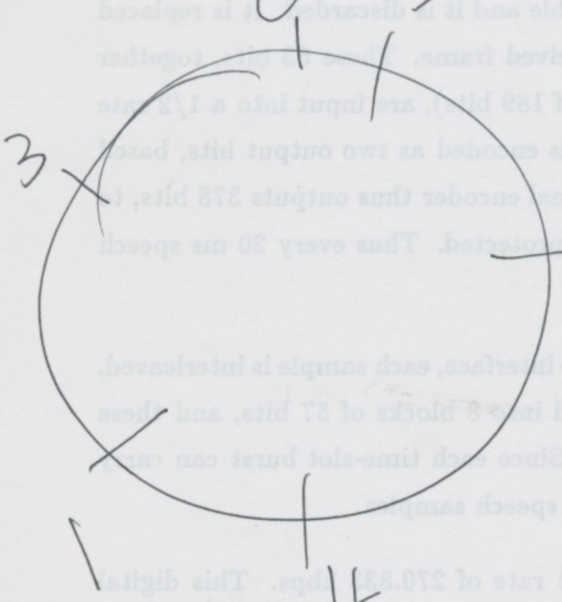
**Class Ib** 132 bits — moderately sensitive to bit errors

**Class II** 78 bits — least sensitive to bit errors

Class Ia bits have a 3 bit Cyclic Redundancy Code added for error detection. If an error is detected, the frame is judged too damaged to be comprehensible and it is discarded. It is replaced by a slightly attenuated version of the previous correctly received frame. These 53 bits, together with the 132 Class Ib bits and a 4 bit tail sequence (a total of 189 bits), are input into a 1/2 rate convolutional encoder of constraint length 4. Each input bit is encoded as two output bits, based on a combination of the previous 4 input bits. The convolutional encoder thus outputs 378 bits, to which are added the 78 remaining Class II bits, which are unprotected. Thus every 20 ms speech sample is encoded as 456 bits, giving a bit rate of 22.8 kbps.

left & right ladders

sequence




To further protect against the burst errors common to the radio interface, each sample is interleaved. The 456 bits output by the convolutional encoder are divided into 8 blocks of 57 bits, and these blocks are transmitted in eight consecutive time-slot bursts. Since each time-slot burst can carry two 57 bit blocks, each burst carries traffic from two different speech samples.

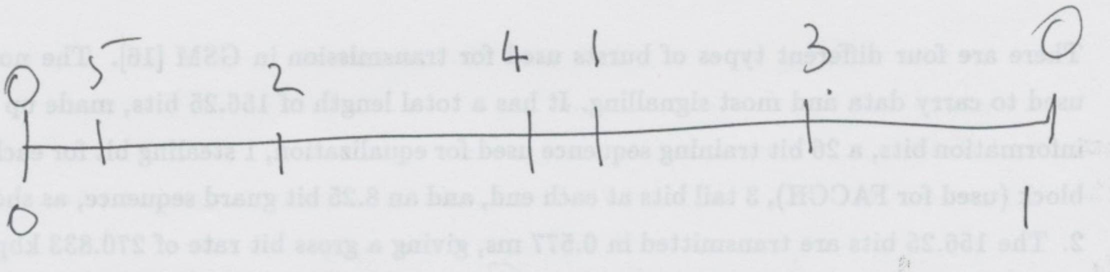
Recall that each time-slot burst is transmitted at a gross bit rate of 270.833 kbps. This digital

next

5,2

OR equivalent

Bed 2




$\# m < n$ st.

$\{m\tau\} < \{n\tau\}$

fractional part

Bud. 3

1's ⇒ Fibs

3's ⇒ Lucas

the parameter of the seq.

$2[(n+1)\tau]+n$

Para table Fib

| | | k: | 0 | 1 | 2 | 3 | 4 | → k |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 1 | 1 | 2 | 3 | 5 | 8 | 13 → 45 |
| 3 | 1 | 3 | 4 | 7 | 11 | 18 | 29 | 35340 |
| 2 | 2 | 4 | 6 | 10 | 16 | 26 | | 35339 |
| 5 | 3 | 6 | 9 | 15 | 24 | 39 | | 35338 |
| 8 | 4 | 8 | 12 | 20 | 32 | | | |
| 5 | 5 | 9 | 14 | 23 | 37 | | | |
| 1 | 6 | 11 | 17 | 35336 | 35337 | | | |
| 5 | p | | | | | | | |

PF

PF 1,2

PF p,k

bottom row

bottom row

20941

Cool. ~~those~~ under 20 & see 8 13

Log

$= [(n+1)\tau]+n$

7065 can now extend

~~= A201~~

~~$[\tau a] = 1029$~~

a

A1514

$\{\tau n\}+1 = [n\tau]$

$[(n+1)\tau] = A201$

every no. appears once

$26355 = [n\tau]+2$

$26351 = [n\tau]+1$

$201 = [n\tau]$

Frame 0-11 : TCH Frame 12 : SACCH Frame 13-24 : TCH Frame 25 : Unused

26 frame multiframe Duration: 120 ms

TDMA frame Duration: 4.615 ms

Tail bits Data bits Stealing bit Training sequence Stealing bit Data bits Tail bits Guard bits

Normal burst Duration: 0.577 ms

Figure 2. Organisation of bursts, TDMA frames, and multiframes for speech and data.

**Broadcast Control Channel (BCCH)** Continually broadcasts, on the downlink, information including base station identity, frequency allocations, and frequency-hopping sequences.

**Frequency Correction Channel (FCCH) and Synchronisation Channel (SCH)** Used to synchronise the mobile to the time slot structure of a cell by defining the boundaries of burst periods, and the time slot numbering. Every cell in a GSM network broadcasts exactly one FCCH and one SCH, which are by definition on time slot number 0 (within a TDMA frame).

**Random Access Channel (RACH)** Slotted Aloha channel used by the mobile to request access to the network.

**Paging Channel (PCH)** Used to alert the mobile station of incoming call.

**Access Grant Channel (AGCH)** Used to allocate an SDCCH to a mobile for signalling (in order to obtain a dedicated channel), following a request on the RACH.

From njas Fri Nov 22 10:31 EST 1996
To: ck6@cedar.evansville.edu
Cc: njas@research.att.com

hi! some time ago you sent me a paper with the following sequence in it:

```
%I A003603 M0138
%S A003603 1,1,1,2,1,3,2,1,4,3,2,5,1,6,4,3,7,2,8,5,1,9,6,4,10,3,11,7,2,12,8,5,13,1,
%T A003603 14,9,6,15,4,16,10,3,17,11,7,18,2,19,12,8,20,5,21,13,1,22,14,9,23,6,24
%N A003603 Fractal sequence obtained from Fibonacci numbers.
%R A003603 Kimb94a.
%O A003603 0,4
%A A003603 njas,mb
%K A003603
```

john conway recently rediscovered this sequence, so i am writing
to ask if that paper of yours

[Kimb94a] = C. Kimberling, ''Numeration systems and fractal sequences,'' preprint, 1994.

has appeared? and if you could send me another copy, of either the
original form or the published version?

thanks!

PS here is jhc's version:

```
%I A019586
%S A019586 0,0,0,1,0,2,1,0,3,2,1,4,0,5,3,2,6,1,7,4,0,8,5,3,9,2,10,6,1,11,7,4,
%T A019586 12,0,13,8,5,14,3,15,9,2,16,10,6,29,1,30,11,7,19,4,20,12,0,21,13,8,
%U A019586 22,5
%N A019586 Takes value i on later (i.e. b_j, j>=2) terms of ith Fibonacci sequence defin
%R A019586 jhc.
%K A019586 nonn
%O A019586 1,6
%A A019586 njas, jhc
```

Neil Sloane, njas@research.att.com, fax: 908 582 2379
AT&T Research Labs, Room 2C-376, 600 Mountain Ave, Murray Hill, NJ 07974 USA
Home page: http://netlib.bell-labs.com/math/sloane/doc/home.html

From cedar.evansville.edu!ck6 Fri Nov 22 11:02 EST 1996
(Smail3.1.29.1 #13) id m0vQy0Z-0002fJC; Fri, 22 Nov 96 09:59 CST
Date: Fri, 22 Nov 1996 10:01:56 -0500 (cst)
From: Clark Kimberling <ck6@cedar.evansville.edu>
To: njas@research.att.com
Subject: Re: your mail
In-Reply-To: <m0vQxeA-0002fXC@evansville.edu>

Neil,

The paper appeared in Acta Arithmetica 73 (1995) 103-117. I'll send you a
copy. (What was the context of John's work that led him to this

sequence?)

From and.Princeton.EDU!conway Sat Nov 23 13:59 EST 1996
Return-Path: <conway>
Date: Sat, 23 Nov 1996 13:43:37 -0500 (EST)
From: John Conway <conway@math.Princeton.EDU>
Subject: Re: parFibs.
To: njas@research.att.com
In-Reply-To: <199611221536.KAA28194@and.Princeton.EDU>

Will you please put the name "para-Fibonacci sequence" in the entry for my version? Correspondingly, perhaps something like "Fibonacci paraphrase" should be in Kimberling's.

I've been continuing my study of these matters, and thinking about the terminology, the most important new pieces of which are the word "parameter" for the index of a sequence, and (Fibonacci) "successor" for the number Sn you get from a given n by bumping up all terms of its Zeckendorff expansion. Thus the sequence with parameter i can be started from

i 1+Si

and after that has the shape

j Sj SSj SSSj SSSSj ...

where j = i + 1 + Si.

On Fri, 22 Nov 1996 njas@research.att.com wrote:

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> Cc: njas@research.att.com
> Status: R
>
> hi! some time ago you sent me a paper with the following sequence in it:
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> %T A003603 14,9,6,15,4,16,10,3,17,11,7,18,2,19,12,8,20,5,21,13,1,22,14,9,23,6,24
> %N A003603 Fractal sequence obtained from Fibonacci numbers.
> %R A003603 Kimb94a.
> %O A003603 0,4

From netcom.com!hbaker Sat Nov 23 14:44 EST 1996
From: hbaker@netcom.com (Henry G. Baker)
Subject: M1,398,269
To: math-fun@cs.arizona.edu
Date: Sat, 23 Nov 1996 11:38:07 -0800 (PST)

Move over, supercomputers

From cs.arizona.edu!rcs Mon Nov 25 16:29 EST 1996
Date: Mon, 25 Nov 1996 14:20:11 MST
From: "Richard Schroeppel" <rcs@cs.arizona.edu>
To: math-fun@cs.arizona.edu
Subject: Fibonacci note from Conway

This came up on another list. I think it's of more interest here on Math-Fun. My apologies to the common membership for a double-post. --Rich

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From: John Conway <conway@math.Princeton.EDU>
Subject: Re: Fibonacci correction from Achim
Date: Mon, 25 Nov 1996 12:51:57 -0500 (EST)

This mention of Fibonacci counting prompts me to pass on something about the Fibonacci's that very much excited me when I found it about a week ago. I've since learned that Clark Kimberling found the essential point about 20 years ago.

I start with the Zeckendorff expansion of a positive integer, obtained by repeatedly subtracting the largest Fibonacci number you can until nothing remains, for example

$$100 = 89 + 8 + 3.$$

By replacing each Fib in the Zeckendorff expansion of n, you get what I'll call the Fibonacci successor Sn, eg.:

$$S100 = 144 + 13 + 5 = 162.$$

Now the positive integers are linked by this function into an infinity of sequences each satisfying the Fibonacci recursion, namely those after the bar in the table below, which covers all numbers below 100:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 1 | 2 | 3 | 5 | 8 | 13 | 21 | 34 | 55 | 89 |
| 1 | 3 | 4 | 7 | 11 | 18 | 29 | 47 | 76 | | | |
| 2 | 4 | 6 | 10 | 16 | 26 | 42 | 68 | | | | |
| 3 | 6 | 9 | 15 | 24 | 39 | 63 | | | | | |
| 4 | 8 | 12 | 20 | 32 | 52 | 84 | | | | | |
| 5 | 9 | 14 | 23 | 37 | 60 | 97 | | | | | |
| 6 | 11 | 17 | 28 | 45 | 73 | | | | | | |
| 7 | 12 | 19 | 31 | 50 | 81 | | | | | | |
| 8 | 14 | 22 | 36 | 58 | 94 | | | | | | |
| 9 | 16 | 25 | 41 | 66 | | | | | | | |
| 10 | 17 | 27 | 44 | 71 | | | | | | | |
| 11 | 19 | 30 | 49 | 79 | | | | | | | |
| 12 | 21 | 33 | 54 | 87 | | | | | | | |
| 13 | 22 | 35 | 57 | 92 | | | | | | | |
| 14 | 24 | 38 | 62 | | | | | | | | |
| 15 | 25 | 40 | 65 | | | | | | | | |
| 16 | 27 | 43 | 70 | | | | | | | | |
| 17 | 29 | 46 | 75 | | | | | | | | |
| 18 | 30 | 48 | 78 | | | | | | | | |
| 19 | 32 | 51 | 83 | | | | | | | | |

| | | | |
|---|---|---|---|
| 20 | 33 | 53 | 86 |
| 21 | 35 | 56 | 91 |
| 22 | 37 | 59 | 96 |
| 23 | 38 | 61 | 99 |
| 24 | 40 | 64 | |
| 25 | 42 | 67 | |
| 26 | 43 | 69 | |
| 27 | 45 | 72 | |
| 28 | 46 | 74 | |
| 29 | 48 | 77 | |
| 30 | 50 | 80 | |
| 31 | 51 | 82 | |
| 32 | 53 | 85 | |
| 33 | 55 | 88 | |
| 34 | 56 | 90 | |
| 35 | 58 | 93 | |
| 36 | 59 | 95 | |
| 37 | 61 | 98 | |
| 38 | 63 | | |

The topmost series is the Fibonacci series itself: I call the n'th one beneath it the n'th extra Fibonacci sequence. It occurs to me that "n'th higher Fibonacci sequence" might be better. The 0'th higher Fib sequence is of course the Fib sequence itself.

Of course each of these sequences can be continued indefinitely far to the left, and I continued them two places left in the table, because then, as you can see, the leftmost column contains the parameter n just defined.

It's a very nice fact that EVERY sequence that satisfies the Fibonacci recurrence and ends up with positive integers is one of this neatly-parameterized family. This leads us to what I call the "para-Fibonacci sequence), which for every positive integer gives the parameter of the Fib-sequence that contains that integer (after the bar):

0 0 0 1 0 2 1 0 3 2 1 4 0 5 3 2 6 1 7 4 0 8 5 3 9 2 10 6 1 11 7 4 12 0 13

Kimberling called the sequence whose terms are 1 larger than these "the paraphrase of the Fibonnaci numeration system".

This has very nice properties - for example between any two consecut 0's we see a permutation of the first few positive integers, and these nest, so we can read the paraFib sequence from:

```
0
0
0                1
0          2     1
0     3    2     1     4
0   5 3    2   6 1   7 4
0 8 5 3 9  2 10 6 1 11 7 4 12
```

Also - if you delete the first occurrence of each number, the sequence is unchanged.

There are many intriguing problems here, of which I'll mention just two:

1) Reading the nth sequence backwards, we obtain the negative of another. Which?

2) Multiplying the terms of the nth sequence by some positive integer d, we obtain those of another. Which? (The reason I prefer my version to Kimberling's is that the answer to this must be some multiple of d.)

I only just thought of 1). About 2) I note that multiplying the Fib sequence by 2,3,4, 5, 6, 7, 8, 9,10,11 we get sequences
numbers 2 3 4 15 18 21 24 27 30 33,

and that the double of the 7th sequence comes before that of the 5th.

I have long been interested in what I call the "budding sequences", which tell you where the successive buds on suitable kinds of plant are located. The paraFib sequence helps to explain many properties of these, and shows that they each consist of the terms of the rather mysterious sequence

1, 3, 2, 5, 8, 5, 9, 5, 10, 15, 9, 15, 21, 13, 20, ...

repeated infinitely often in systematic ways. However, to explain these matters here would take me as much time again, and I want to have some lunch now!

John Conway