A Proposed IEEE 802.11 Radio Lan Architecture

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Abstract

There has been a reasonable amount of work done by the IEEE 802.4L group in identifying technical challenges in the radio communications pertaining to Lan connectivity through wireless media. It is clear that the challenges viewed through 802.4L may differ to some extents with respect to 802.11 standards. Here, an attempt is made to put together an architecture where most of the relevant known technical issues related to 802.11 can be overcome or circumvented. This architecture is presented here in a very high level manner by intent. The reason is to solicit agreements and comments before more detail analysis is carried out to avoid wastage of resources.

High Level Issues Affecting Architecture

The proposed architecture is attempted to overcome the following problems which are of some concerns:

1) One of most difficult problems is the distribution of head-ends in a single network. The reason being that the propagation delay in the wires will cause insurmountable delay spread distribution. One brute force solution is to do a time and phase synchronization of the head-ends and cables. Technically, in a consumer product arena, this is a non-solution.

2) The Doppler frequency issue arises from the need of the wireless nodes in motion while in communication. The velocity of the wireless node issue has been seen many a great intellectual debate in the 802.4L group. However, when one considers that there is a great consensus among the hardware designers that the reference frequency stability is to be accepted as 2×10^{-5}, it is easy to see that for the likely frequency spectrum for 802.11 of 2 Ghz, the equivalent doppler effect to a stationary node is significant. One would not contemplate of specifying frequency tolerances of any greater accuracy in a consumer product of this nature. Thus coherence time is an important issue beyond the desire to make the wireless node a stationary one to simplify the design problem.

3) The speed of synchronization has also been discussed. Here, two assumptions are made. One is that under the current regulatory climate, the use of spread spectrum technique is necessary. Spread spectrum technique also presents a number of useful properties that greatly reduced the complexity in combating propagation related problems. The other assumption deals with the desire to keep the transmission half duplex. This is because of the likely spectrum constraints and the advantage of much reduced RF design complexity. In this case the synchronization of the spread spectrum code sequence is a concern. There are solutions such as using code corelators. One important issue with the corelators is that the symbol timing has to be of a certain accuracy. This is because the corelator z^{-1}

unit delay is fixed in the design of SAW or CCD devices. A minor consideration is that the device is frequency and code length dependent. Undoubtedly, the advent of the ultra high speed DSP processor can perform the corelator despreading function by direct DSP, however, the expense of such an approach is not compatible with a consumer product at its infancy currently.

4) A secondary, but thorny technical problem is that of the architecture of the distribution systems. Inter-system communications and the logistics of locating a node is a good example.

Definition of Basic Service Area

In order to proceed further, it is necessary to define "Basic Service Area" (BSA). BSA concept has been mooted previously, however this term is borrowed here with no relationship to previous known definition of BSA. A BSA is an area serviced by a head-end that covers a basic cell. The word "cell" is also borrowed loosely from the cellular telephony service and carries the same meaning as BSA in this context.

A BSA head-end is an autonomous head-end controlling its own cell coverage. It has two interfaces. One is the radio interface where it transmits and receives at an assigned frequency band called Forward Communications Interface (FCI). The other is a directly connected point to point medium (wire or wireless) called Reverse Communication Interface (RCI).

The BSA Concept

In this section only the BSA is considered. As a rule, BSA should be as small as possible. It will be evident from current cellular literature that this is the case. More in depth discussion will be prepared if the need arises.

The BSA head-end (BSAHE) maintains a slotted Aloha, Demand Assigned Multiple Access protocol at its FCI and its RCI is served by any suitable Lan protocol dependent on usage. In the wireless case of RCI, a regular point to point terrestrial or satellite link can be used.

Consider only the FCI for the moment. When a BSAHE is installed and powered up the first time, and there is no other BSAHEs in operation in its immediate vicinity (a point that will be covered later), it listens for other BSAHEs for a fixed time interval, then transmits in all time slots except three. A time slot is measured in a fixed number of data bits. One of the three time slots is called the Aloha slot, and the other is the local acknowledgement (LACK) slot. The third slot is [SYNC] and will be discussed later. The contents of the transmission can be designed later, and they are not the immediate subject of discussion here. The idea of a long transmission time is to allow all the nodes within the BSA to gain correct clock synchronization. It is now obvious that in this way the correct clocking will always be maintained because the nodes will also transmit pseudo- coherently (another point that will be discussed later).

When a node that wishes to begin contact will transmit in the Aloha slot. It will convey its address and the intended connections address. BSAHE would acknowledge the receipt of the Aloha request, in the next time slot with the sender and the receiver addresses.

All nodes are designed to listen on the time slot immediately after Aloha slot, this is a mandatory listen time slot. If the addressed receiver is within the BSA, it will respond with its status during the LACK time slot. BSAHE will then assign bandwidth to the data session according to the load of the traffic. The format will be that [Sender1 Slot] [BSAHE repeat slot] [Receiver1 ACK/NACK] [Sender2 Slot] [BSAHE repeat slot] [Receiver 2 ACK/NACK]...[Aloha] [BSAHE poll] [LACK]. Once a bandwidth is assigned between two nodes, the sender and the receiver can interchange time slots for return traffic. The protocol to do this can be designed later. During the connection, the bandwidth assignment is continuously adjusted as function of the traffic. The adjustment is broadcasted by BSAHE during the repeat slot.

Now, if the Aloha request by a node is Nack'ed by the BSAHE, the node will continue to try by skipping N numbers of the Aloha slots, where N is a random number selected after each try. The node will time out after a pre-determined number of trials.

If the receiver does not Ack during the [LACK] slot, BSAHE will then send the contents of its [BSAHE poll] transmission to all BSAHEs on the Lan connection through its RCI.

When a BSAHE receives a [BSAHE poll] slot content from its RCI, it will broadcast it in its own [BSAHE poll] slot as soon as possible. If a positive [LACK] is received, then the BSAHE will assign a "simplex" bandwidth to the local receiver. The format will be [BSAHE RCL] [receiver Ack/Nack]. In the reverse direction, the receiver can assume the [BSAHE RCL] bandwidth and the protocol for this to happen can be designed later.

The originating BSAHE will withhold assigning bandwidth until its RCL request to all other BSAHEs is replied through the Lan connection. If a connection is established then, a similar simplex bandwidth is also assigned locally.

A preset time out for the unsuccessful bandwidth assignment will take effect both in the node and the BSAHE.

From this description a simple picture of the BSA concept hopefully is becoming clear. The figures appended is intended for a graphical illustration of the concept.

BSAHE to BSAHE Synchronization Protocol

The concept of basic BSA is described above. It is also established that inter BSA link is by suitable regular Lan connections. However, the relationship between adjacent BSAs needs attention. A group of 4 BSAs or 7 BSAs is called An Extended BSA (EBSA). This definition is also different from the previous 802.4L terminology. The significance of the group of 4 or 7 or larger is that this grouping method is extensively use by Cellular Telephony analysts, and thus the analysis is well understood. The 4 or 7 cells re-use analysis will almost directly applicable in the same manner in terms of 4 or 7 code divisions re-use. Each BSAHE is programmed with its primary code and it is knowledgeable about all the codes that are re-used in its environment.

So, when a BSAHE is initially powered up. it listens to all the BSAHEs through all the known codes. If other BSAHEs are heard, it would try to lock its very narrow frequency reference loop to it. Being a narrow loop this loop is more tolerant to low and noisy signals. If none is heard then it will allow its frequency reference free run at the nominal frequency.

If a signal is locked to, the update to the synchronization is maintained through the silent [SYNC] slot.

The [SYNC] slot is not a fixed time slot, it is chosen randomly and broadcasted to its BSA nodes when the [SYNC] slot takes place. The reason is that in this way [SYNC] will not be biased by the propagation parameters such as a static fade. The reason for the synchronization of all BSAs is to allow a node to move uninterruptedly from a BSA to another BSA.

The [SYNC] slot is also listen to by all nodes, the nodes will compute expected signal strengths from each of the code divisions. The signal strength number will serve as a prompt for possible crossing to the next BSA.

When a node detects the [SYNC] of an adjacent BSAHE being higher in signal strength than the current BSAHE it is listening to, it would try to aloha into the stronger BSA. The same entry process is used. If it is successful in entering the next BSA, it would terminate the old BSA bandwidth, and continue the connection with its file transaction within the new BSA. There should be no break in file transaction during this BSA Transfer Process (BSATP). This is very much akin to the "hand-off" in the cellular telephony system.

The BSATP is carried out in the following sequence:

$m \neq n$,

Sender:-

BSA(code m):-[Sender][BSAHE][Receiver A/NACK] .... [Aloha][BSAHE poll][LACK].....[SYNC code n=n+1]
if signal strength of code n $\gg$ that of code m, then,
BSA(code m):-[Sender][BSAHE][Receiver A/N] .....[code: n Aloha] [Code: n BSAHE ack][null LACK]...
BSAHE(code n):-
FCI: [Aloha][BSAHE ack][null LACK]...
RCI: [BSAHE ack]...set up link... [Assign bandwidth]..[simplex]
BSA(code m):-[Sender terminates]

Receiver:-

BSA(code m):- [Sender][BSAHE][Receiver]...[Aloha] [BSAHE poll–Receiver] [Receiver LACK]...[Sender–last slot][BSAHE][Receiver]..... [Receiver simplex] ..

Implications of the BSA concept

As mentioned at the beginning, the discussion here is limited to the very high level architectural concept. Finer points of this architecture can be opened to further discussion. However, by adopting this architecture, there are some nice leeways in combating the problems listed at the beginning.

1) By having an autonomous BSA, the small users are not penalized by paying for features necessary for larger networks. This is very important for a consumer product because of initial outlays of cost for the system.

2) By the EBSA concept, the users can tailor the need of their coverage area with unnecessary cost that associated with larger granularity. In most cases, a large user would normal have a high speed back bone lan server for the EBSA.

3) BSA concept by its nature would drive down the effective radiated RF power. and thus cost, interference, safety and other associated problems will be lessened.

4) As BSA is small, the delay spread is small with respect to its symbol frequency. If one can assure that the delay spread is also larger than the chip time, then a major design hurdle would have been crossed.

5) The coverage strategy is well known in the literature for the integrity of the defined BSA to be preserved.

6) The installation problem is minimized, and the possibility of user installing the system is good.

7) Good possibility for varied means of implementing the standards to provide for different classes of performance versus cost issues. In this scheme, the major design cost that would be needed in securing synchronization is not necessary. Performance enhancement using various classical schemes are simpler to implement, for example RAKE receivers.

8) BSA concept also side step the more difficult problems of propagation characteristics. Each BSA can be tailored to suit its environment, by limiting its coverage, and lower its power. So, for a difficult propagation environment smaller and smaller BSAs and more and more in number will be used. For benign environment the converse is true. Each BSA in an EBSA need not be the same size, however, it has been shown that in cases where the size disparity is large, very careful engineering is needed to prevent the small BSAs being overshadowed. This is a phenomenon where, all the nodes would eventually transfer to the large BSAs.

Conclusion

This concept has not undergone more rigorous thought process, however, it has the advantage of flexibility that allows it to overcome much of the more tricky hurdles. The finer points of the protocols and design issues, will need more analysis.

SLOTTED ALOHA DEMAND
ASSIGNMENT MULTIPLEX
ACCESS SCHEME

(S/ALOHA/DAMA)

with
Autonomous HEAD-ENDS
and
Stack-able expansion

- harsh & benign enviroments
- Multiple Phys
- Voice
- Robust-ness
  Single point of failure
- Volume market
  El-cheapo to niche
- ease of use
- power consumption
  (≈ Circuit Simplicity)
  Low power possible
- Single station serviced
  multiple phys
- Varied data rate in the
  same network. (ε restrictions)
- mobile station, roaming (fixed
  or moving) Moving station
- cost of start-up network
  and expansion

- coverage flexibility
- true wireless (backbone)
  supported
- MAN, WAN transparency
- AND those stated in
  the paper.

(1) To work on Architectural
Physical Defects only

(2) Protocol defects to be considered
out of scope.

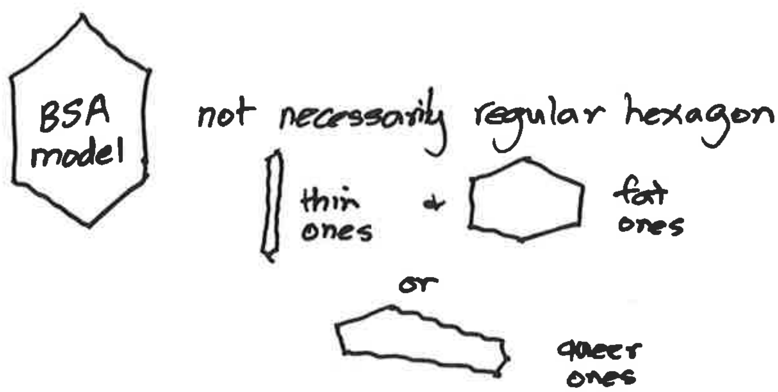
(1)

Definitions : (Arbitrarily decided, if they need change, I not a man of principle, I accept any thing)

$\boxed{\text{BSAHE}}$ (A.K.A access point.)

Nodes (A.K.A. user equipment remote station)

BSA — an as-small-as-possible coverage by BSAHE
"coverage" — to be discuss later.



Nodes — half duplex transceiver — transmitter on Receiver off + versi versa

Structure of BSAHE

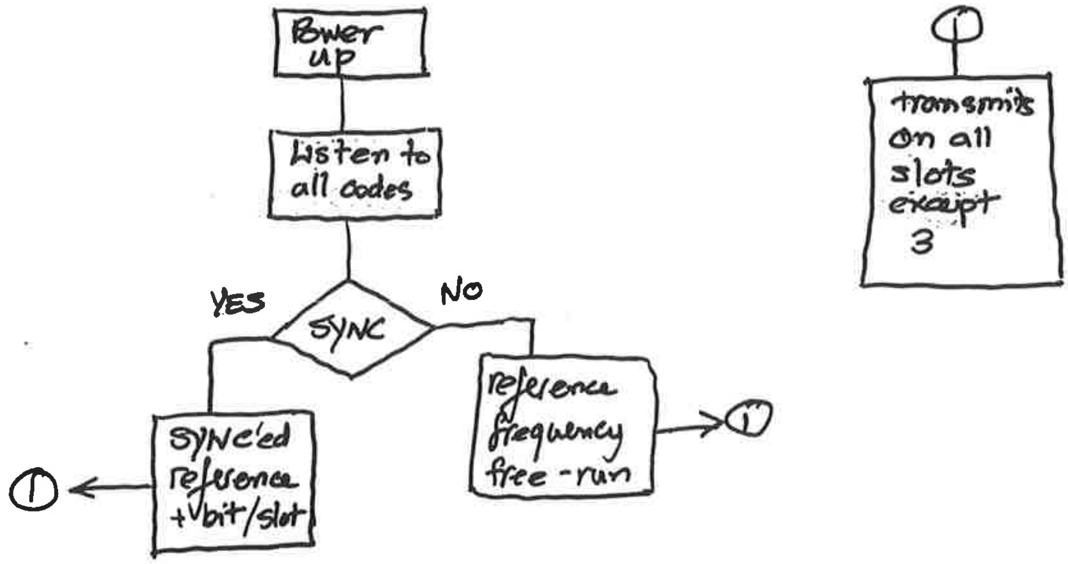
RCI
"GOD"
FCI

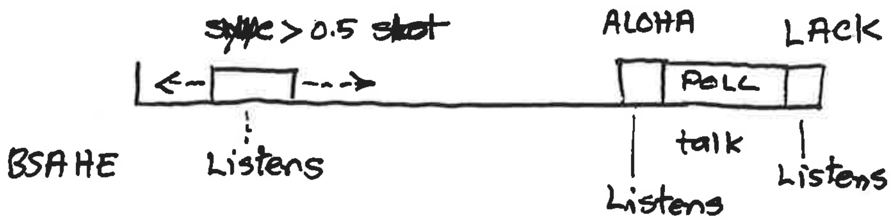
Assumptions :(see pp 1 No. 3)
1) half duplex
2) SS.

(2)

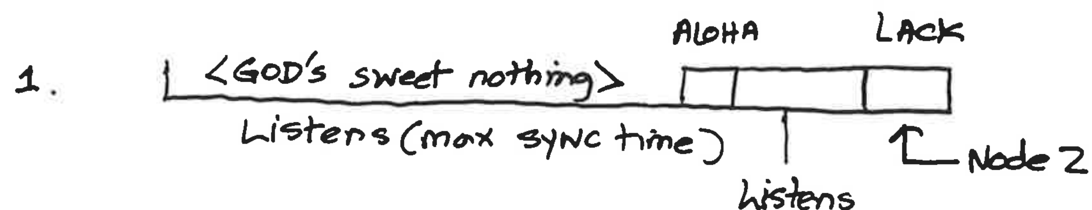
Begin of Time 3

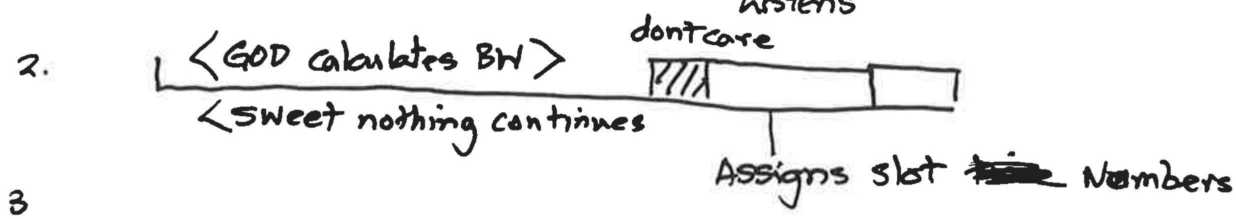
BSAHE

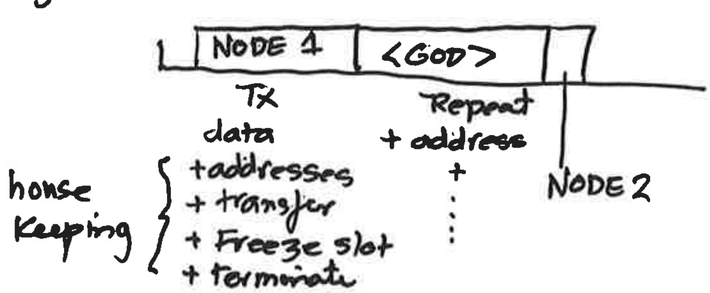




NODE 1 → NODE 2







Once BW is assigned NODE 1 / NODE 2 can exchange tx/RX roles with housing keep

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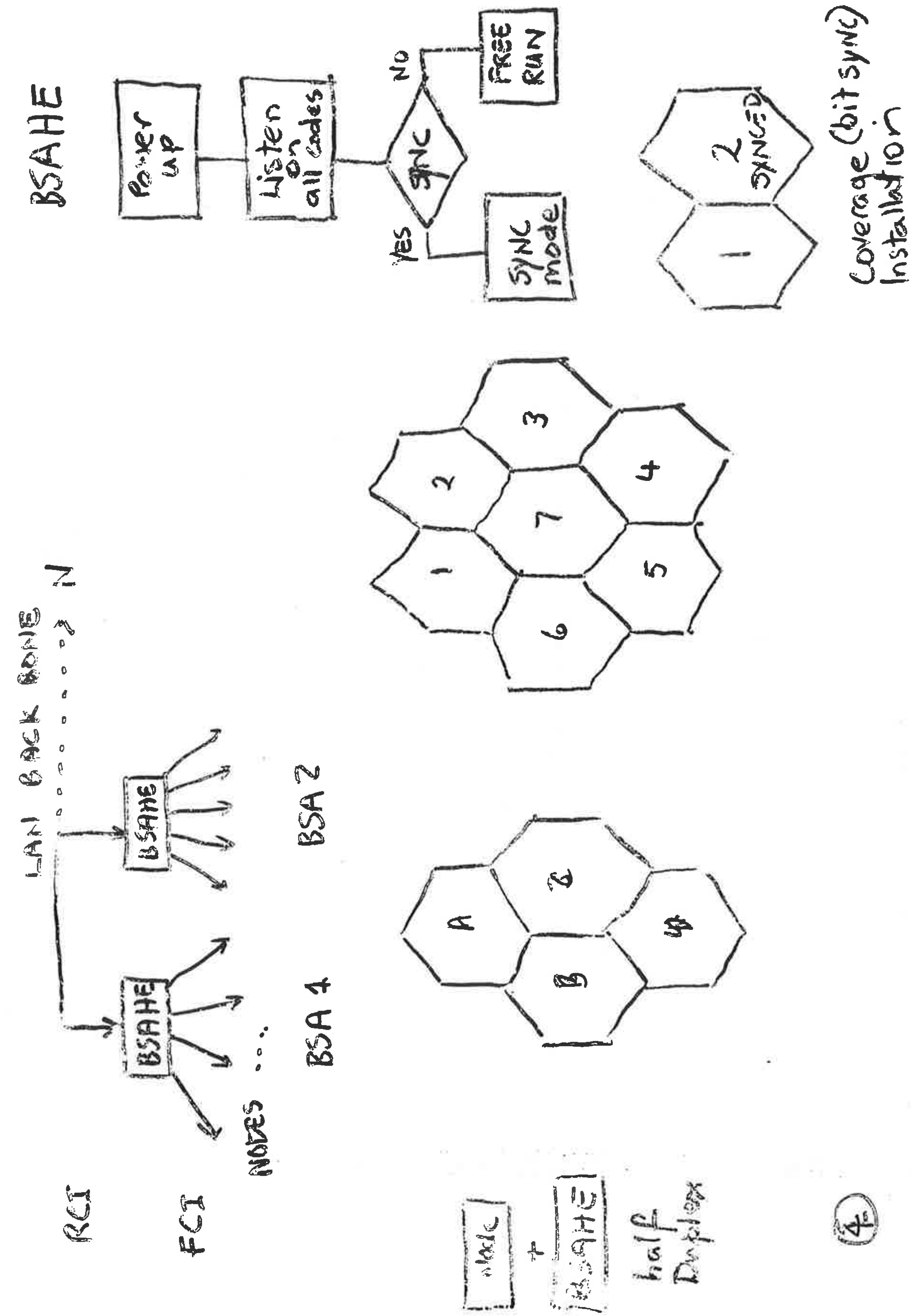
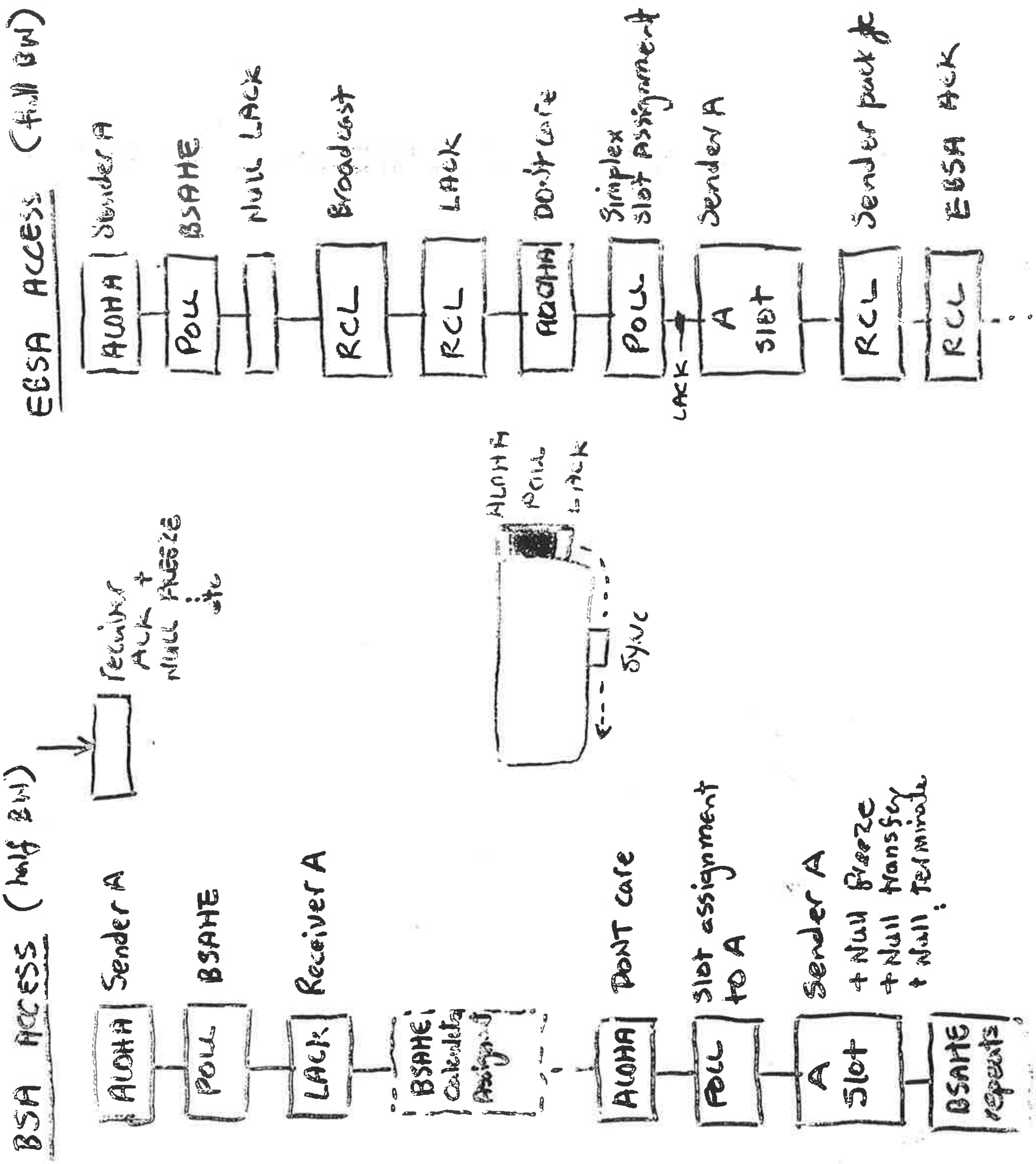
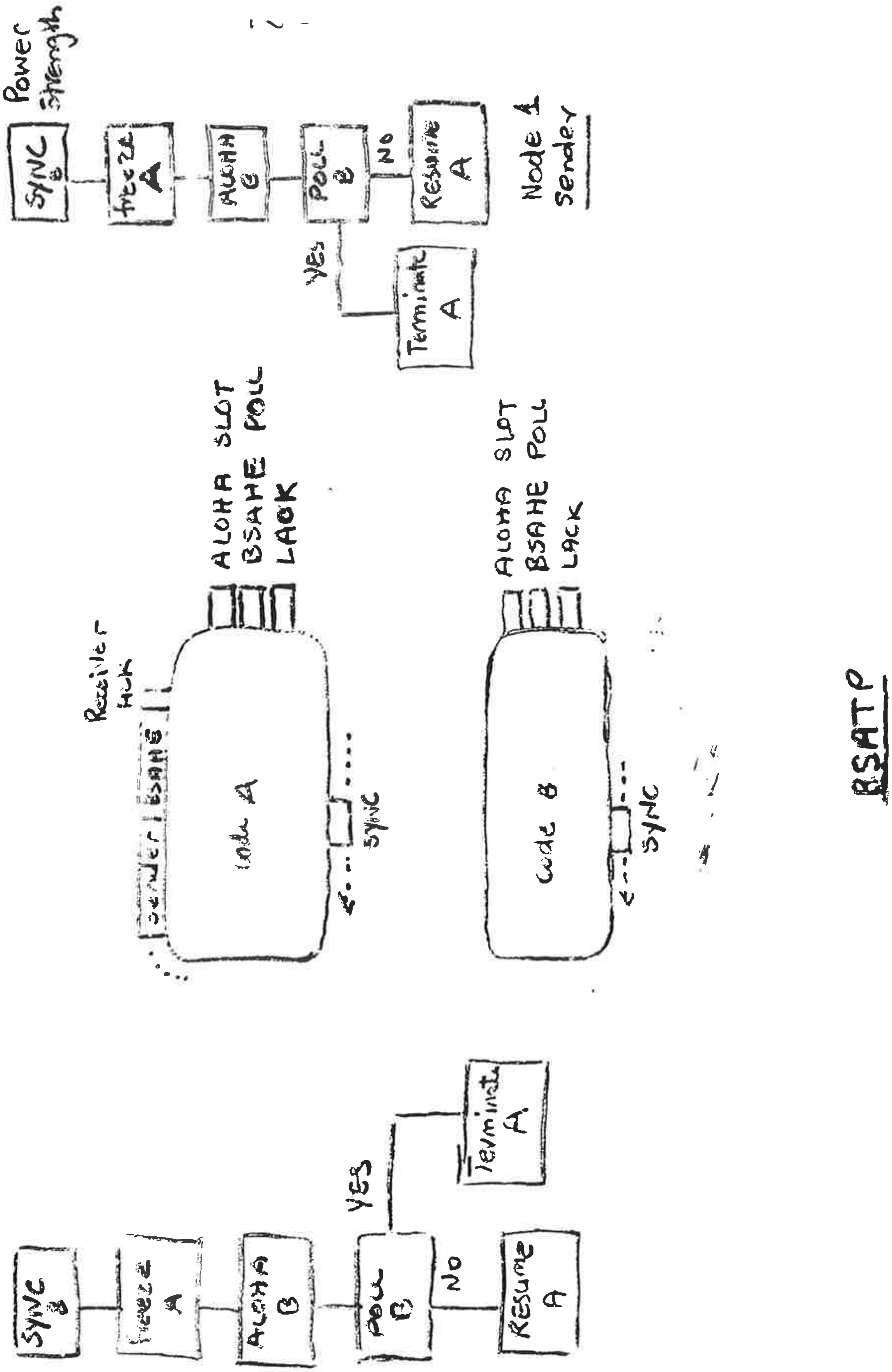

BSAHE
Power up
Listen on all codes
SYNC
YES
NO
SYNC mode
FREE RUN
1
2 SYNCED
Coverage (bit sync) installation
LAN BACK BONE
N
BSAHE
BSAHE
BSA 2
BSA 1
NODES
1
2
3
4
5
6
7
A
B
RCI
FCI
Node
+
BSAHE
half Duplex
4

5

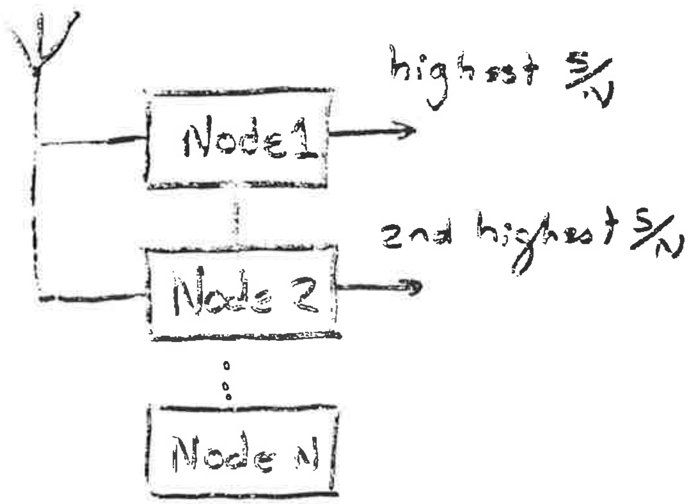

EBSA ACCESS (full BW)
ALOHA
Sender A
POLL
BSAHE
Null LACK
RCL
Broadcast
RCL
LACK
ALOHA
Don't care
POLL
Simplex Slot Assignment
LACK
A slot
Sender A
RCL
RCL
EBSA ACK
Receiver ACK + Null freeze etc
ALOHA
Poll
LACK
Sync
BSA ACCESS (half BW)
ALOHA
Sender A
POLL
BSAHE
LACK
Receiver A
BSAHE Calendar Assigned
ALOHA
DONT care
POLL
Slot assignment to A
A Slot
Sender A
+ Null freeze
+ Null transfer
+ Null terminate
BSAHE repeats


Power Strength
SYNC B
Freeze A
ALOHA B
POLL B
No
Resume A
YES
Terminate A
Node 1 Sender
ALOHA SLOT
BSAHE POLL
LACK
Receiver ACK
Sender
BSAHE
Node A
SYNC
Node B
RSATP

1. Very Small (1 BSAHE) system possible
2. Incremental growth of Network
3. Very low cost terminal possible.
   High cost terminal can be design independent of specification.
4. Solve propagational problems with high density small BSA coverage
5. Super flexibility in system configuration

High cost example:-

1. Dual Node Redundancy.



2. RAKE Receiver

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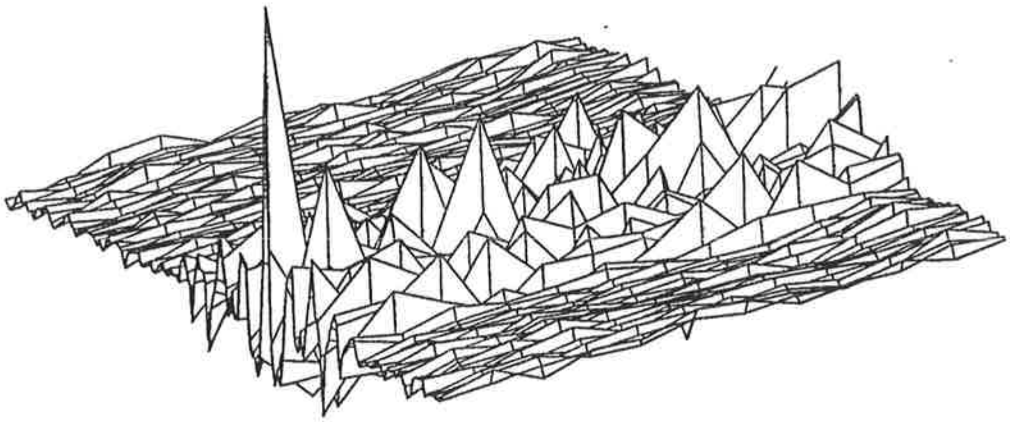
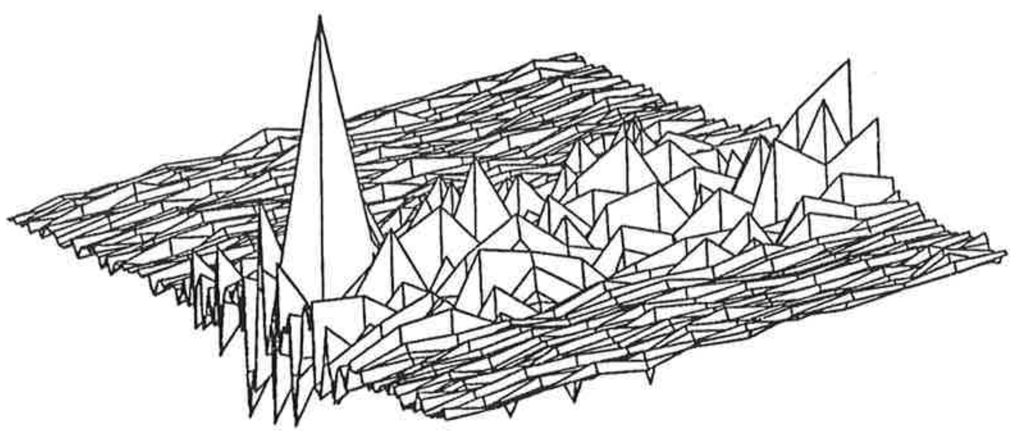
7

31-bit 12-vector Gold code correlation profile



31-bit 12-vector Gold code correlation profile



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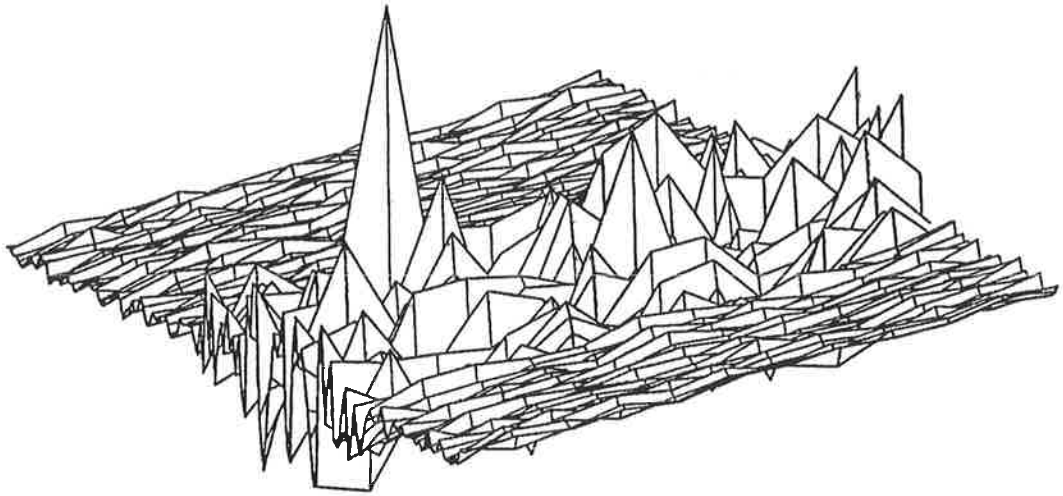

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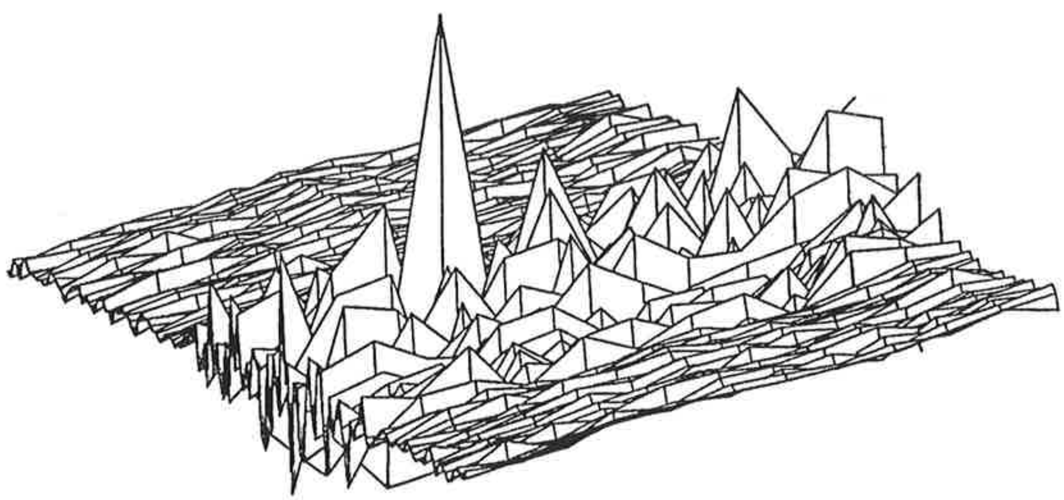

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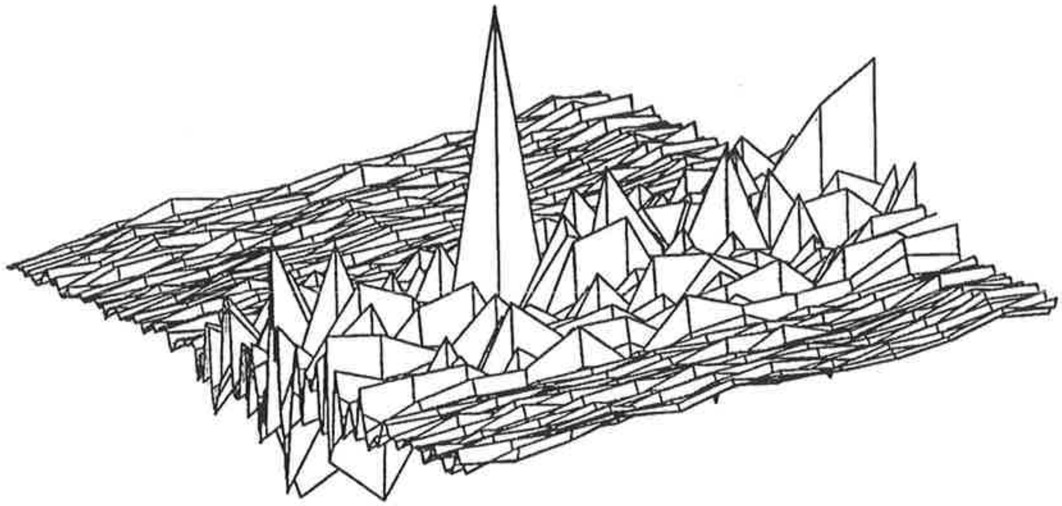
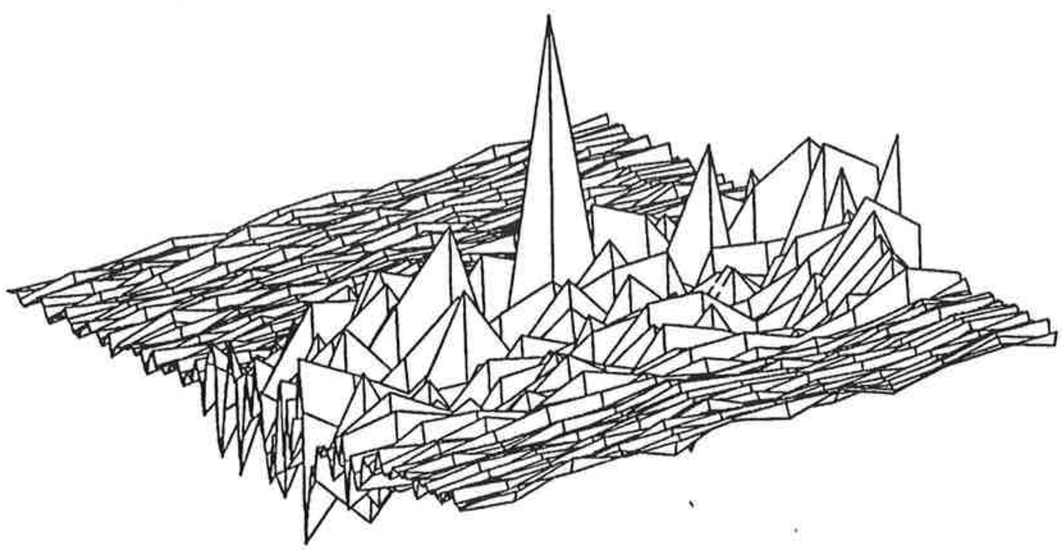
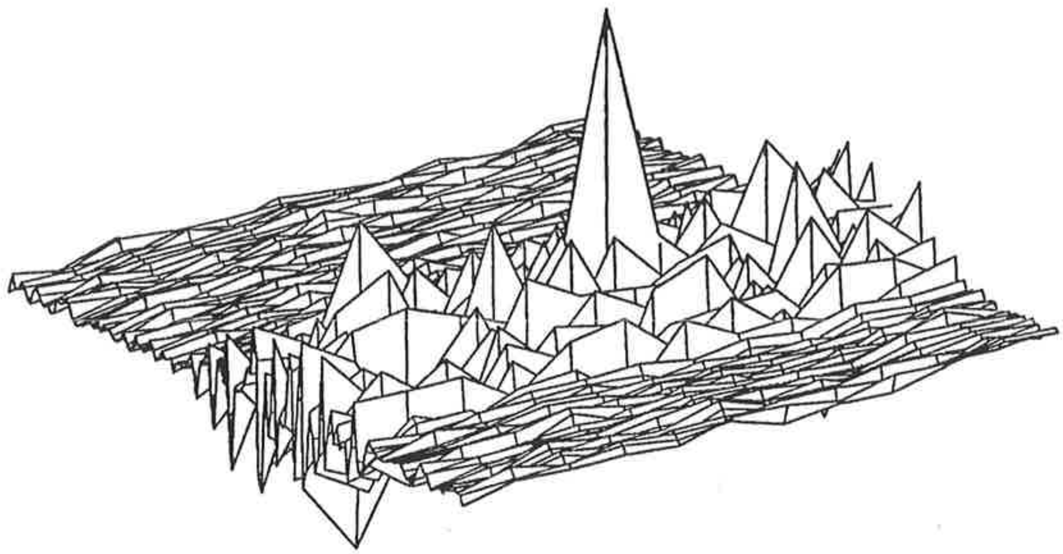
31-bit 12-vector Gold code correlation profile



31-bit 12-vector Gold code correlation profile



31-~~bit~~ 12-vector Gold code correlation profile



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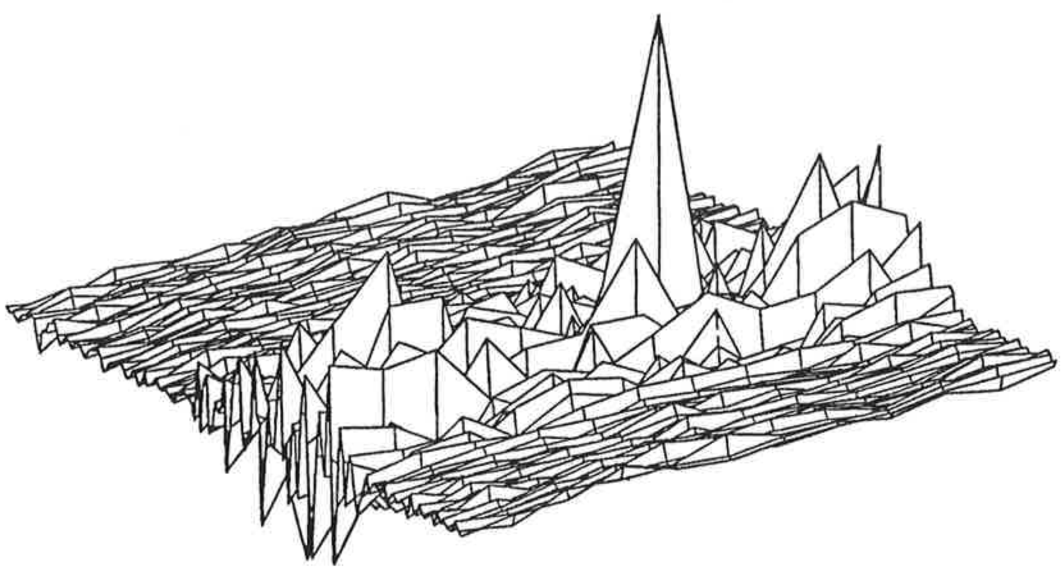

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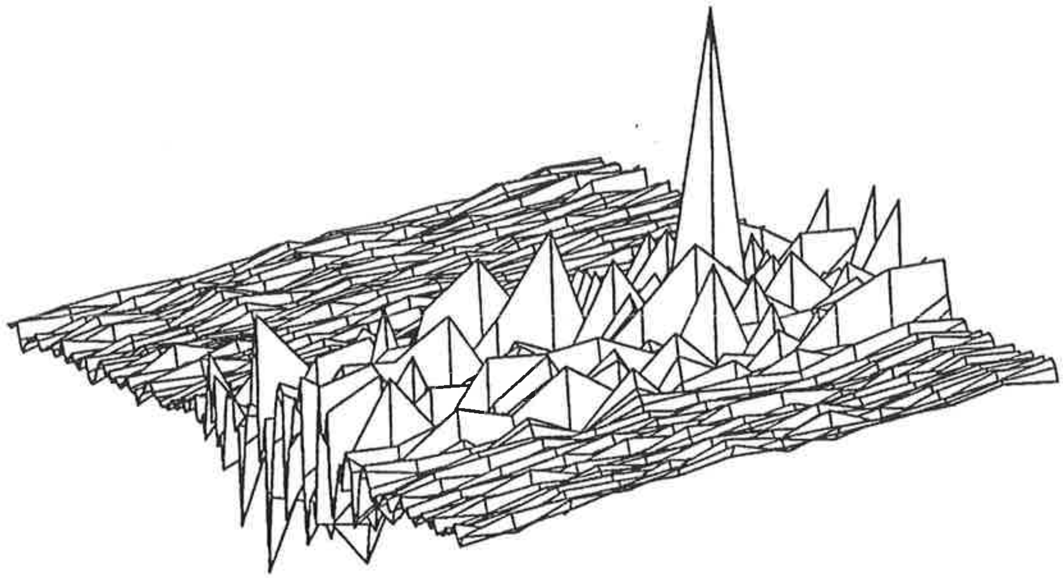
31-bit 12-vector Gold code correlation profile



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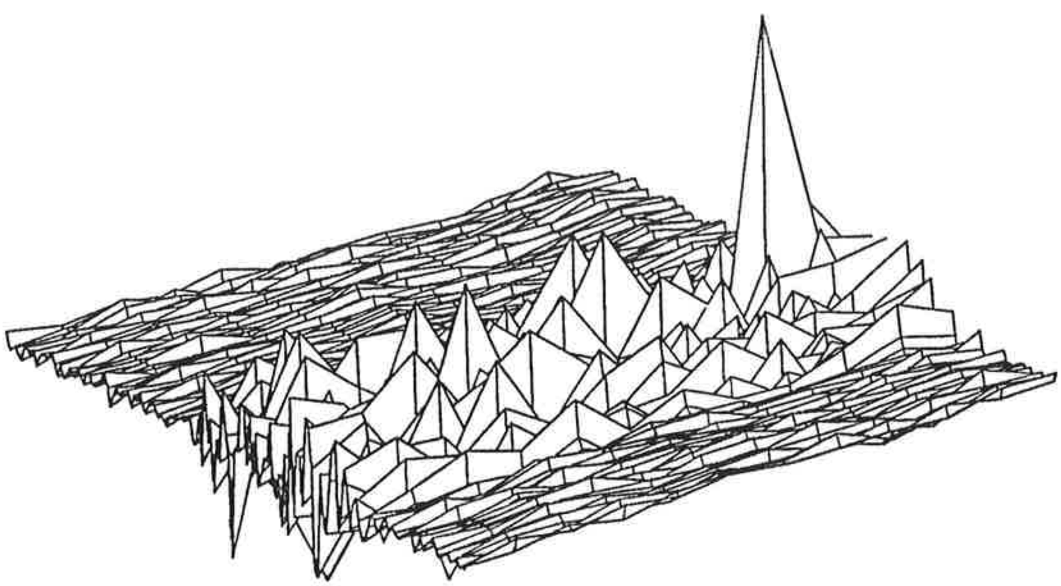

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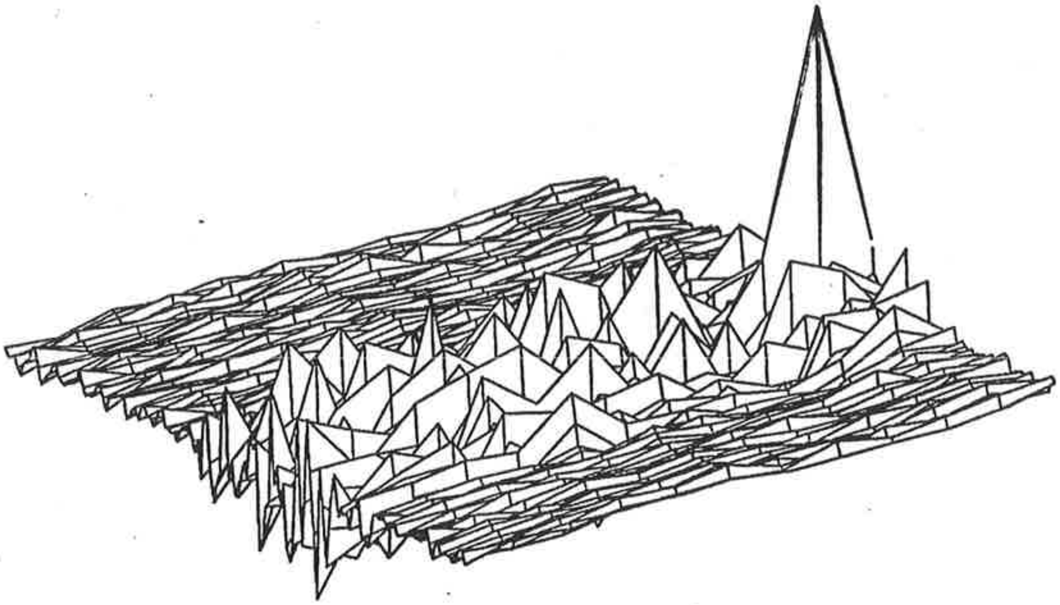

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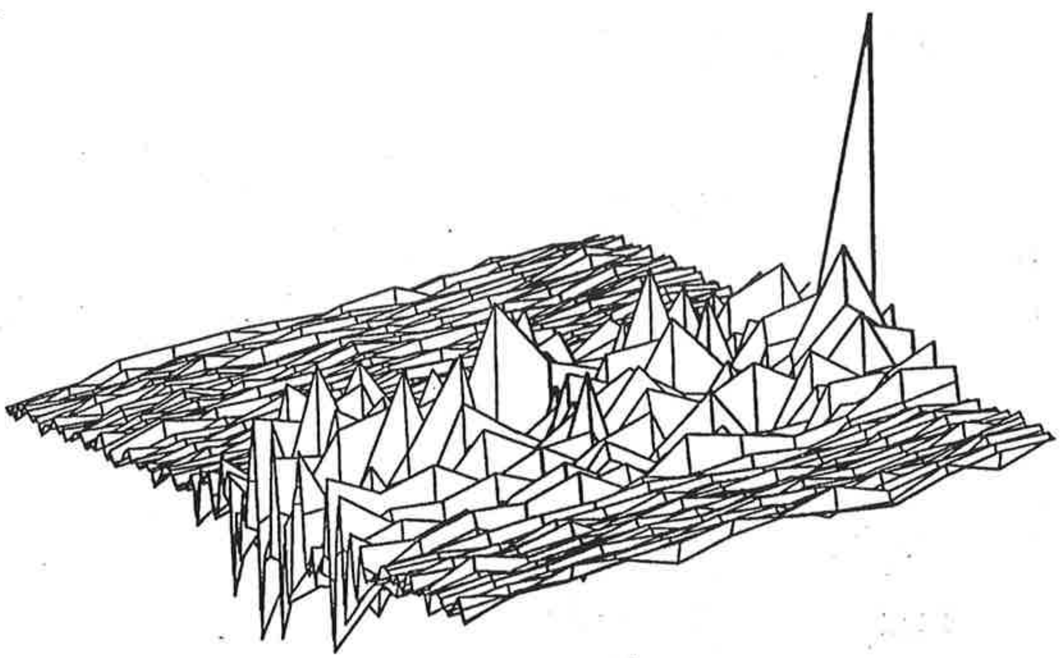

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