TeNeT Group
IIT Madras

Seminar Series on MIMO-OFDMA Cellular Systems

Module-1

OFDM/OFDMA Fundamentals –

Generalised Multi-Carrier (GMC)

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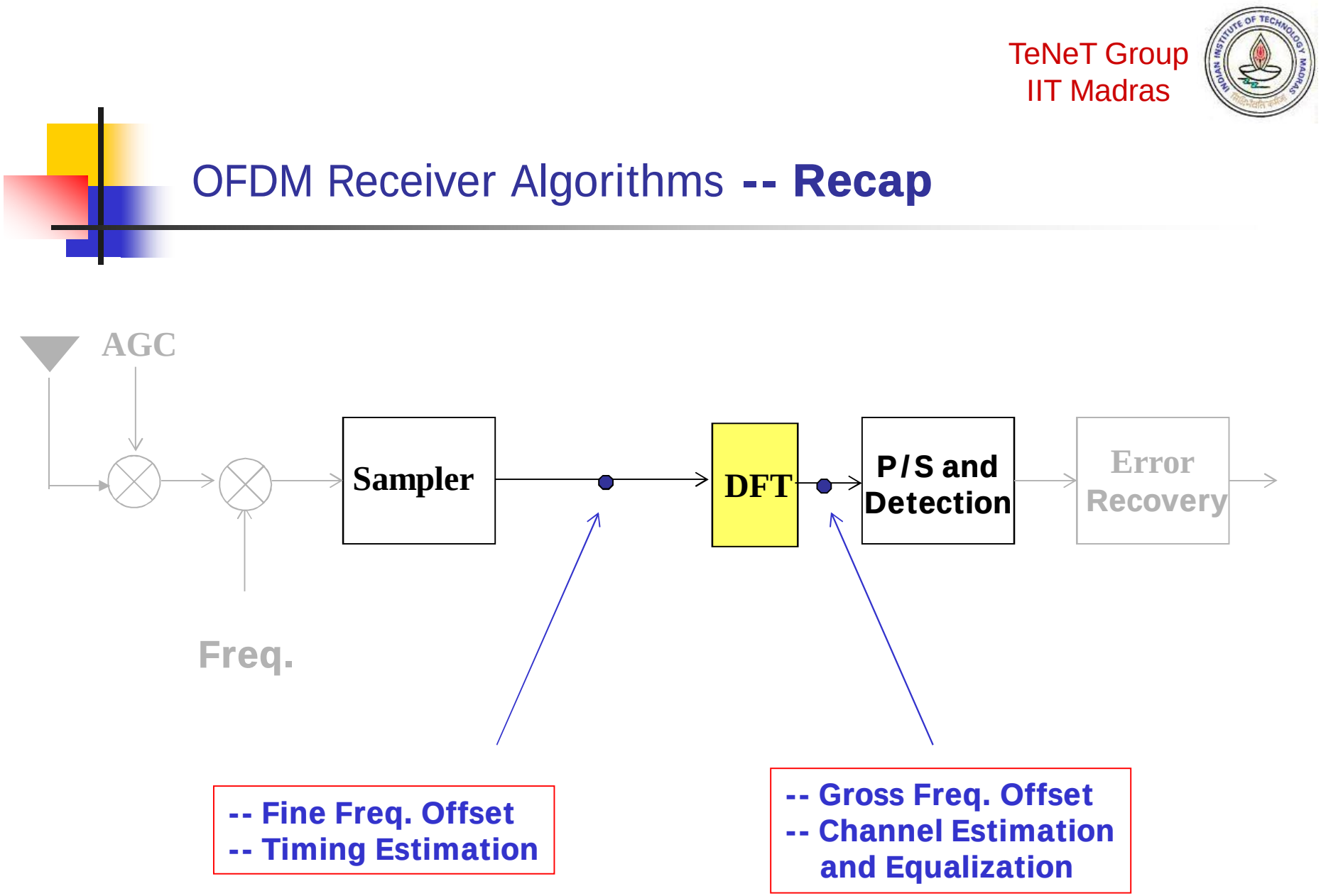
OFDM / OFDMA Fundamentals – contd. 2

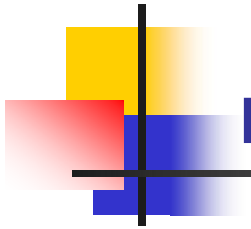
- Generic OFDM Tx model
  - Understanding PAPR

- **OFDM -- CP based Multi-carrier Block Tx**
  - Symbol-by-symbol Tx vs Block Tx
  - Single-carrier vs Multi-carrier Block Tx
  - Block Tx with Cyclic Prefix (CP), or Unique Word (UW), or Zero Padding (ZP) – Which gives what?

- Simple OFDM Rx (measurement) model
  - Time domain
  - Freq. domain



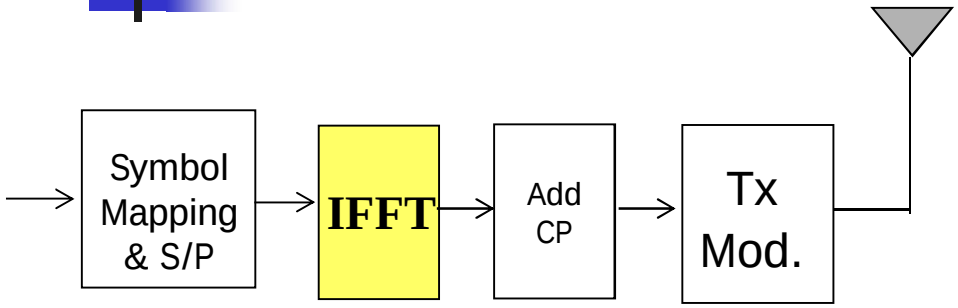
OFDM Receiver Algorithms -- **Recap**



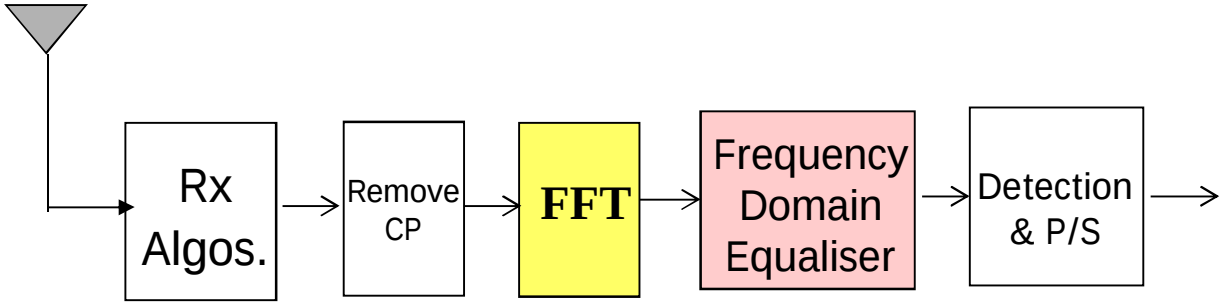
Block Tx flavours

- **Multi-Carrier with**
  - **Cyclic Prefix (CP)**
  - **Zero-Padding (ZP)**
- **Single-Carrier with**
  - **CP**
  - **ZP**
  - **Unique-Word (UW)**

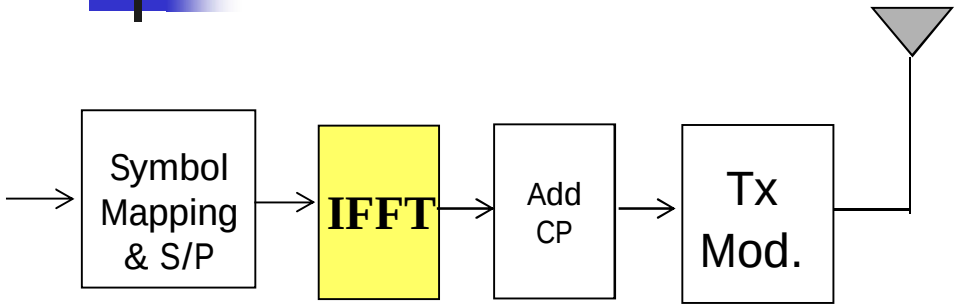
FDE -- Conventional OFDM



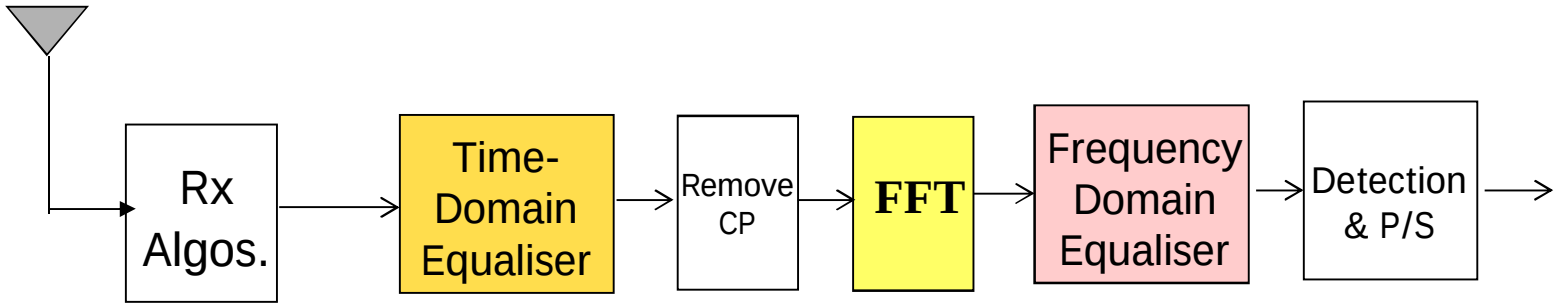
Conventional OFDM



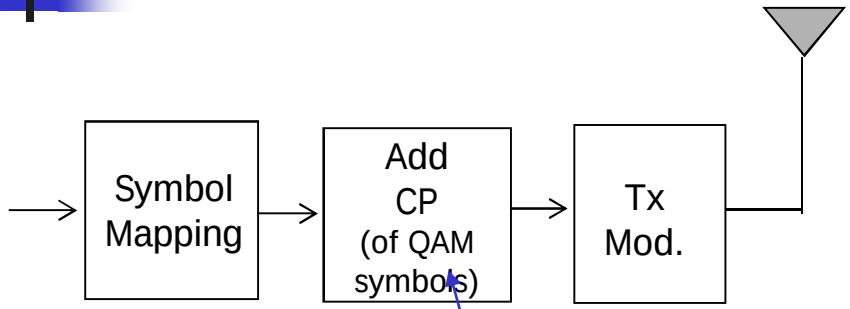
Time & Frequency Domain Equalisation
-- for OFDM in large delay spread channels



TDE + FDE for OFDM

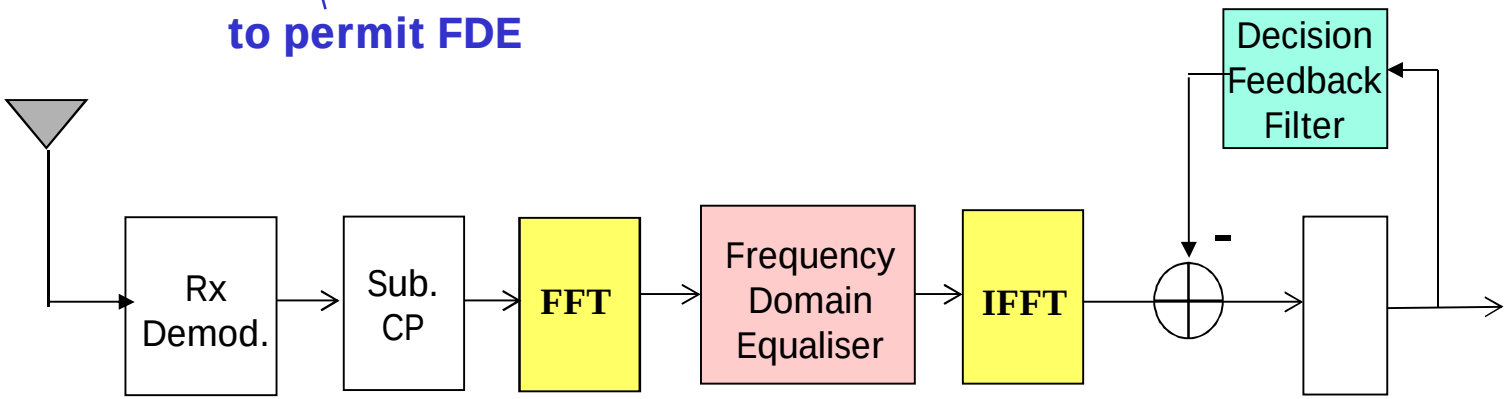


Frequency Domain Equalisation -- Single Carrier FDE (SC-FDE)



to permit FDE

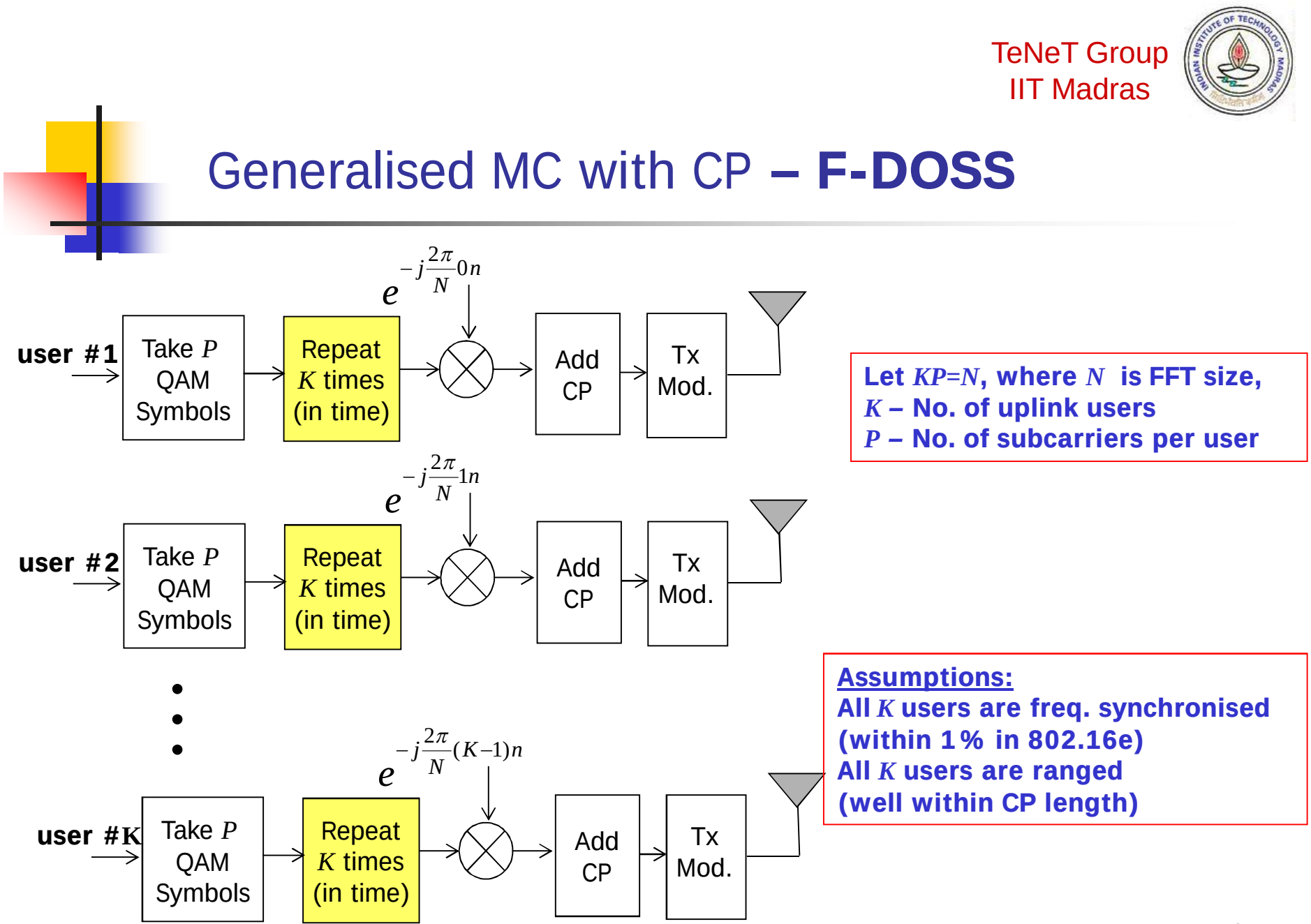
Tx -- low-complexity, TDMA
Rx -- implements SC-FDE;
Linear Equaliser or DFE



Single Carrier & Generalised Multi-Carrier

- **Single Carrier with CP offers**
  - **Low PAPR**
  - **Freq. Diversity** (since each QAM symbol "sees" the entire BW)
  - **Ability for multiplexing** (of different user streams on down-link)
  - **However, <u>not</u> suitable for up-link**
    - **(a) poor link margin!**
    - **(b) multiplexing requires CP between every user burst – inefficient**

- **Generalised Multi-carrier modulation for the Uplink**
    - **Provides narrow-banding => higher link margin!**
    - **Provides freq. domain multiplexing – spectrally efficient**
  - **F-DOSS – Freq. Domain Orthogonal Spread Spectrum**
    - Chang & Chen, IEEE Comm. Letters, Nov.2000
  - **Interleaved OFDMA (I-OFDMA) or DFT spread OFDMA**
    - 3GPP LTE has adopted this for UL

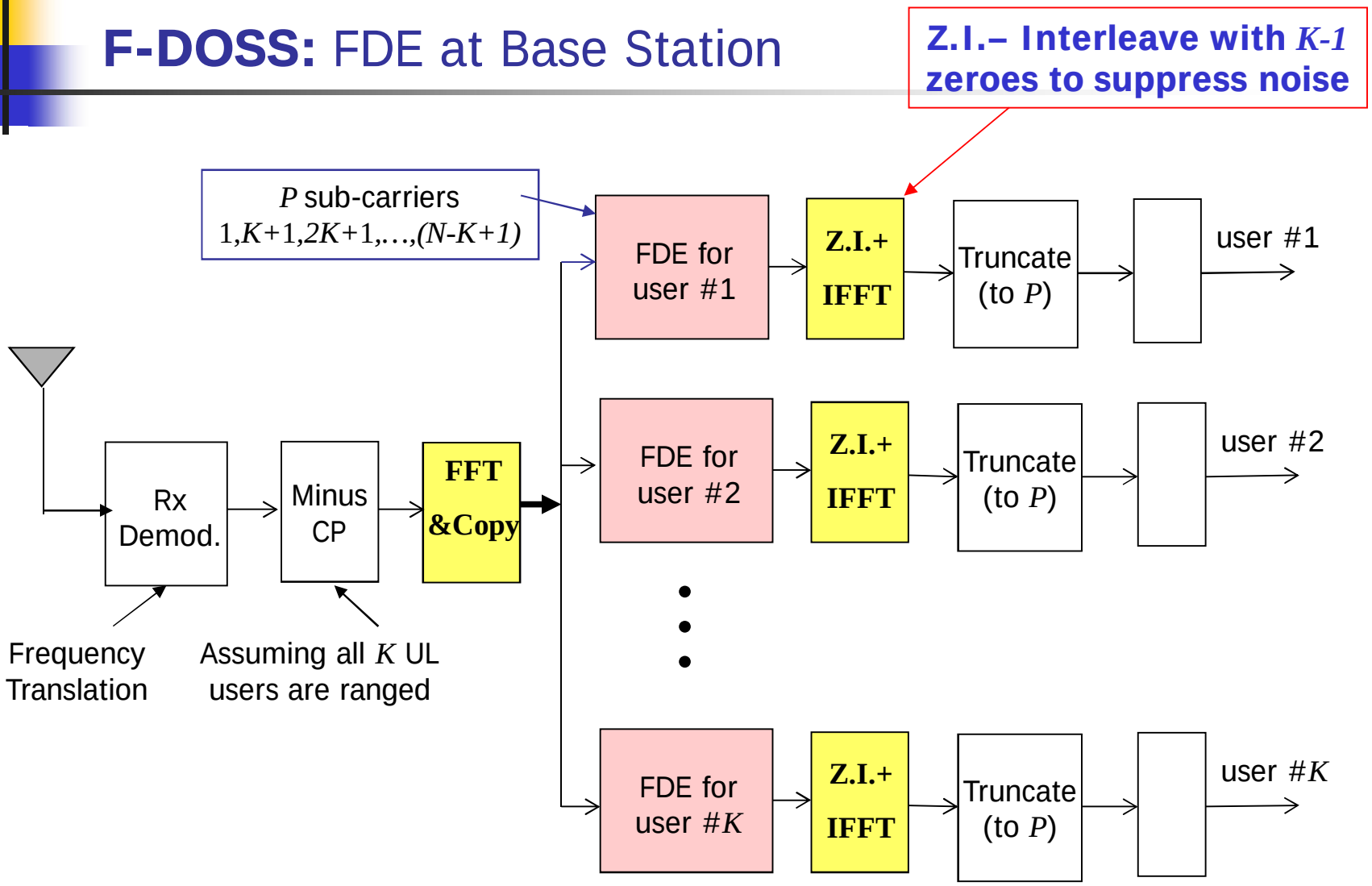


Generalised MC with CP – **F-DOSS**

Let $KP=N$, where N is FFT size,
K – No. of uplink users
P – No. of subcarriers per user

Assumptions:
All K users are freq. synchronised (within 1% in 802.16e)
All K users are ranged (well within CP length)

F-DOSS: FDE at Base Station

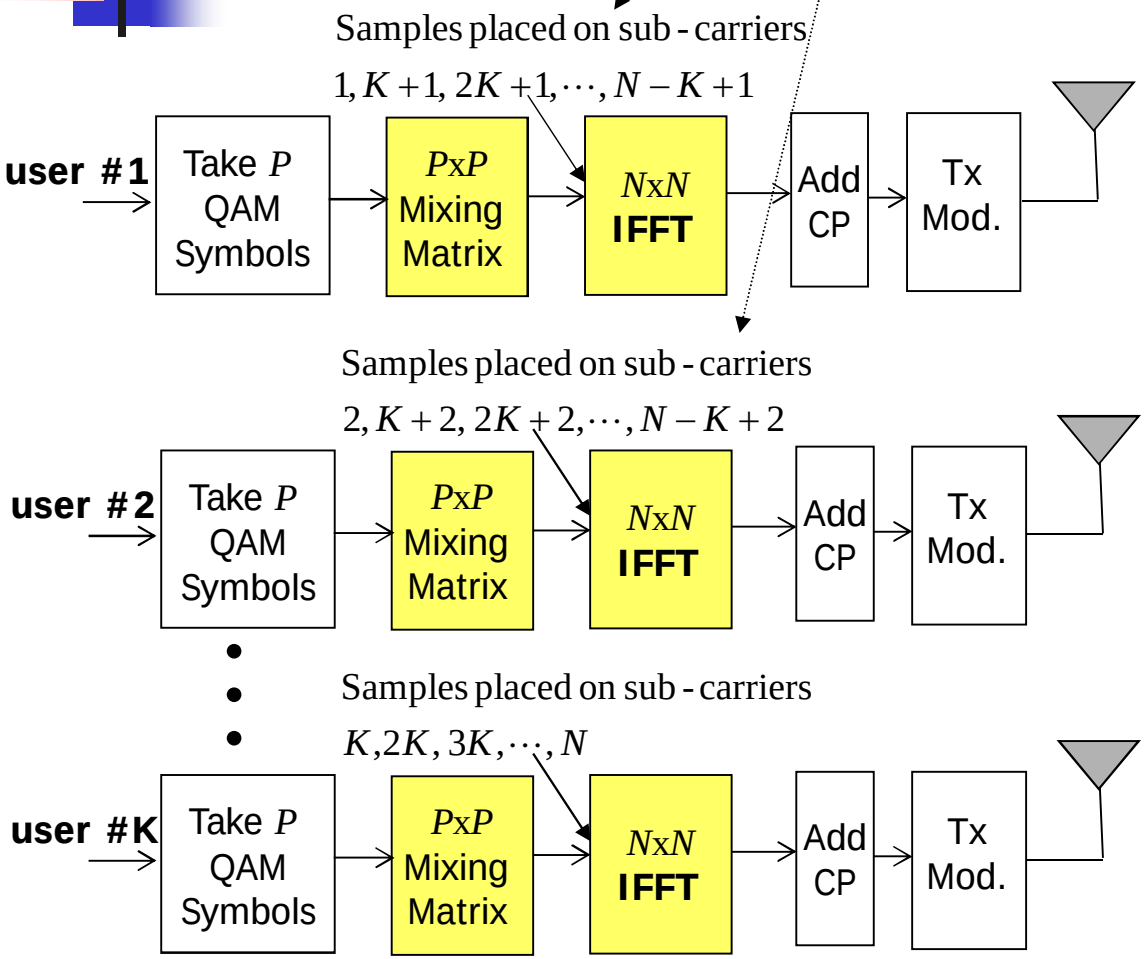


Single Carrier to Generalised Multi-Carrier -- **Motivation**

- **F-DOSS offers**
  - **Ability for multiplexing Uplink users efficiently**
  - **Low PAPR**
  - **Low Computational complexity**
  - **Better link margin (by a factor of $N/P=K$ for each user)**
  - **But, flexibility is limited**
    - since each user stream "goes thro" uniformly spaced (*K*-spaced) subcarriers
    - also, each QAM symbol only present in *K* (of *N*) transmit samples
- **Interleaved OFDMA**
  - **Some PAPR increase+ increase in computational complexity**
  - **But, ensures more flexibility**
    - User stream can occupy any *P* out of *N* sub-carriers (like OFDMA)
    - Each QAM symbol is present on all the *N* transmit sample
    - **Question: Does this "ensure" better CCI averaging in reuse-1 systems?**

Generalised MC – Interleaved OFDMA

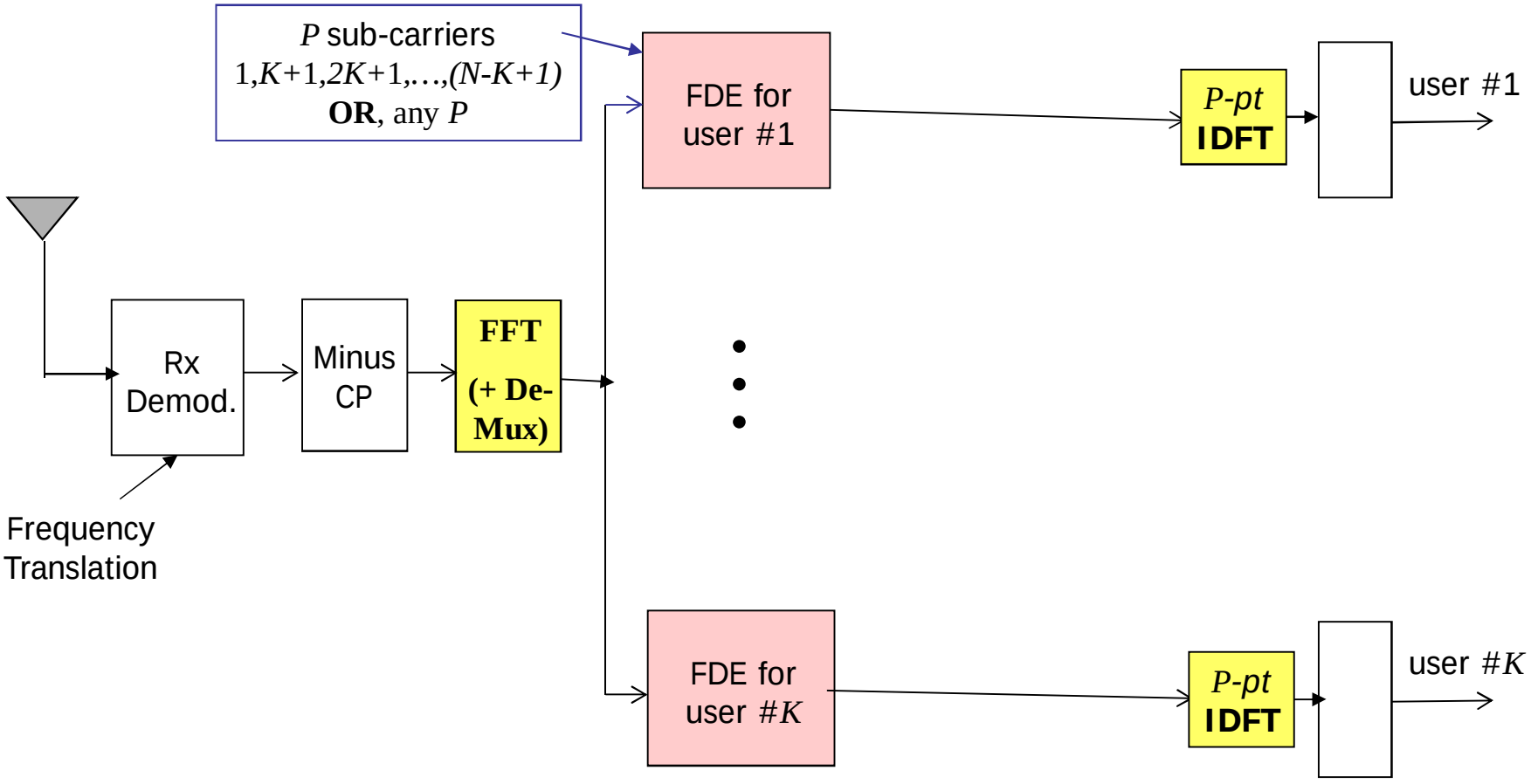
To mimic FDOSS



Let $KP=N$, where N is FFT size,
K – No. of uplink users
P – No. of subcarriers per user

Mixing Matrix can simply be a K point DFT matrix!

I-OFDMA: FDE at Base Station



Summary/Pending issues (GMC)

- In GMC techniques, channel estimation requires "lumped" pilots
  - Use sys-ID in time domain to estimate CIR
  - Solve Wiener-Hopf (MMSE) equations to define LE/DFE of required order either in TD or FD
- Study the pilot-allocation in the UL of LTEs
- Understand impact of CCI on UL