the signal transmission through the optical filter at the PD and the current by a PD whose responsivity is $R_{\text{pd}}$. The transmitted signal $x_t$ is the signal $x_t$ that propagates through the wireless channel and impinges upon the PD at the receiver. The overall channel gain between the LED and the PD is denoted by $G_x$, which is expressed as 

\[
G = \frac{(m + 1)}{2\pi} \cos^m(\phi)g_{\text{pl}}A_{\text{pd}}T_{\text{sc}}g_{\text{sc}} \cos(\psi),
\]

where $m$ is the mode number of the radiation lobe given by $-\ln 2/\ln(\cos \Phi)$, where $\Phi$ is the angle at which the radiated power reduces to half compared to the power radiated along the normal of the plane containing the LED, the angles $\phi$ and $\psi$ are as depicted in Fig. 1, $g_{\text{pl}}$ is the optical path loss between the LED and PD which models the propagation of optical signal in space, $A_{\text{pd}}$ is the area of the PD, $T_{\text{sc}}$ models the signal transmission through the optical filter at the PD and $g_{\text{sc}}$ is the concentrator gain of a non-imaging concentrator.

The received (optical) signal is converted into an electrical current by a PD whose responsivity is $R_{\text{pd}}$. The current signal is converted into voltage signal by a transimpedance amplifier (TIA) whose gain is $R_F$. The electrical signal at the TIA output is expressed as

\[
Y_t = R_F(R_{\text{pd}}Gx_t + \Omega_t),
\]

where $\Omega_t$ is the additive white Gaussian noise (AWGN) noise which is dominated by shot noise of the PD and the thermal noise of the resistor of the TIA. The received signal is sampled, quantised and passed through fast Fourier transform (FFT) block. Assuming that the D/A and analog to digital (A/D) converters are time and frequency synchronised, the output of the discrete Fourier transform (DFT) operation yields

\[
Y_k = R_F(R_{\text{pd}}Gx_k + \Omega_k),
\]

where $\Omega_k$ is the noise observed on subcarrier $k$, whose power $N = E[|\Omega_k|^2]$ is expressed as

\[
N = 2qR_{\text{pd}}P_{\text{am}}B_{\text{sc}} + \frac{4k_B T B_{\text{sc}}}{R_F},
\]

where $q = 1.6 \times 10^{-19}$ C, $P_{\text{am}}$ is the intensity of ambient light incident on the PD, $k_B$ is the Boltzmann’s constant, $T$ is the absolute temperature and $B_{\text{sc}}$ is the bandwidth of a subcarrier. In this paper, clipping noise [9] and noise due to non-linear transfer function of the LED [20] are ignored as these parameters are not central to the contributions of this paper.

III. INTERFERENCE COORDINATION IN OPTICAL CELLS

A simplified model of the optical wireless cellular system considered in this paper is depicted in Fig 1. The available OFDMA subcarriers are grouped in contiguous blocks made up of $n_{sc}$ subcarriers and $n_{os}$ OFDM symbols. Such blocks form a resource unit called a chunk and is denoted $(\kappa, n)$ where $\kappa$ is the frequency index and $n$ is the time index. Let $\mu$ denote a UE which is associated with an AP $\alpha$. Likewise, UE $\nu$ is another UE which is served by AP $\beta$, where $\beta \neq \alpha$ using the same chunk that is used by AP $\alpha$ to serve UE $\mu$. Therefore, AP $\alpha$ causes CCI to UE $\nu$ and AP $\beta$ causes CCI to UE $\mu$.

In order to distinguish between intended and interfering signals, the channel gains (2) are distinguished by adding subscripts of the form $G_{\alpha,\mu}$ where the first subscript denotes the transmitter and the second one denotes the receiver. Likewise, a transmitter index is added to the transmitted symbol to distinguish the symbols transmitted by different transmitters. To this end, $X_\alpha$ is used to denote the symbol transmitted by transmitter $\alpha$. The subcarrier indices are omitted for clarity, since the equation apply to an arbitrary chunk in the system.

From the perspective of UE $\mu$, the desired and interfering signal power can be expressed as

\[
\begin{align*}
R^d_{\mu} &= E[|Y^{\text{des}}|^2] = E[|RFGx_{\alpha,\mu}X_{\alpha,\mu}|^2] \tag{6} \\
I^d_{\mu} &= E[|Y^{\text{inf}}|^2] = E[|RF_{\mu}G_{\beta,\mu}X_{\beta,\mu}|^2]. \tag{7}
\end{align*}
\]

Since the subcarriers are assigned in chunks, the signal-to-interference-plus-noise ratio (SINR) is constant for all subcarriers within the chunk. The SINR at UE $\mu$ on chunk $(\kappa, n)$ is expressed as

\[
\gamma_{\mu}[\kappa, n] = \frac{R^d_{\mu}[\kappa, n]}{R^d_{\mu}[\kappa, n] + N} \tag{8}
\]

\[
= \frac{(R_{\text{pd}}G_{\alpha,\mu}[\kappa, n]p)^2}{(R_{\text{pd}}G_{\beta,\mu}[\kappa, n]p)^2 + N},
\]

where it is assumed that the transmit power (electrical) on each subcarrier is $p^2$. 

![Diagram of OFDM modulation for optical wireless](image_url)

![Assignment of subcarriers in optical OFDM](image_url)