**Lab 3：Symbol Synchronization**

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| **Introduction**  Experimental objective: Master symbol synchronization technology  **1.Principle of maximum energy method**：  Algorithms used to optimize the performance of wireless communication systems. The principle is to allocate energy as much as possible to the target receiver during transmission to achieve maximum received signal quality. Determine the characteristics of the transmission channel, including factors such as path loss and channel fading. Calculate the energy loss from each transmission node to the receiver: Calculate the energy loss from each node to the receiver based on parameters such as transmission distance and path loss. Allocate transmission power of transmission nodes: Based on the energy loss calculation results, allocate the transmission power of each transmission node to minimize the total energy loss. Optimize transmission strategy: By adjusting the position of nodes or changing the transmission strategy, further optimize the transmission effect.    **2. Principle of Early Late Gate Algorithm：**  Used to solve the problem of multipath interference in wireless communication. The principle is to reduce or eliminate multipath interference by adjusting the observation window of the received signal and selecting the best reception timing. Pre processing of received signals: Pre processing of received signals, including filtering, amplification, and other operations. Delay estimation: By observing the characteristics of the received signal, estimate the time difference of arrival on different paths, i.e. the delay time of multipath propagation. Time window adjustment: Based on the estimated delay time, adjust the observation window of the received signal to better receive signals on the main path and reduce the impact of multipath interference. Signal reconstruction: Reconstruct the signal in the adjusted observation window into the original signal for subsequent processing and decoding      **Lab results & Analysis**：  1. Maximum energy method (program diagram, programming process, simulation results)    2. Curve of symbol synchronization accuracy with upsampling factor    3. USRP measures signal transmission delay, explains measurement results (offset and delay), and analyzes the relationship between them.      **Frequency offset** refers to the difference between the actual frequency of a signal and the expected frequency. It can lead to phase offset and changes in the signal transmission speed. Frequency offset often results in timing issues in signal transmission, particularly at the receiving end.  **Delay** refers to the time delay experienced by a signal during transmission. It can stem from factors such as the length of the signal transmission path, the propagation speed of the medium, and the processing time of the signal processing system. Delay can have an impact on signal synchronization and accuracy.  There exists a relationship between frequency offset and delay. In general, frequency offset can cause timing synchronization errors. The greater the frequency offset, the poorer the signal synchronization, leading to larger delays. Additionally, delay can also affect frequency estimation of the signal since it alters the phase relationship of the signal.  4. Early and late gate algorithm testing.    **Note**: Please indicate meaning of the symbols in all expressions. Please indicate the coordinate and unit in all figures. | |
| **Experience**  **蔡浩宇**        **曹子惠**      **Hardware Experiment Challenges:**  Ensuring proper calibration and synchronization of usrp is crucial for obtaining accurate results. And Signal interference and noise in the hardware setup can impact the performance of the symbol synchronization algorithm. For example, in usrp, only get fitting Trigger level can we have perfect results.  **Experience**  We have solid understanding of symbol synchronization algorithms and their practical implementation is crucial for achieving accurate and reliable results. And thoroughly testing and verifying the implemented symbol synchronization module is essential to ensure its robustness and effectiveness. By the way, Real-world conditions, such as channel impairments and noise, should be considered in the simulation or hardware experiment setup to obtain more realistic and applicable results. | |
| **Score** | 100 |