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Q3: As an add-on, you are required to install a VGA camera (640x480 pixels, 8 bits per pixel) to monitor the status of the growing process. Is the solution proposed at the previous points still valid? If not, propose an alternative solution.

R:----------

Integrating a VGA camera into the monitoring system introduces complexity and bandwidth requirements that may impact the feasibility of the ZigBee solution. While ZigBee remains viable for transmitting low-bandwidth sensor data such as luminosity (2 Bytes), sugar content (2 Bytes), and pH values (1 Byte) due to its low power consumption and ability to handle periodic transmissions, it may not be suitable for transmitting high resolution camera images (with 640x480x8=2.4576Mbit/s).

Sensor data transmission is well suited for ZigBee as it involves relatively small amounts of data, easily manageable within ZigBee's specified range and frequency bands. However, transmitting VGA resolution images poses challenges due to ZigBee's maximum data rate of around 250 kbit/s, insufficient for high resolution images, especially if transmitted frequently.

Furthermore, ZigBee's operating frequency bands and limited range might not be adequate for transmitting high resolution images over longer distances. While suitable for monitoring within a small university lab, it may not suffice for broader applications.

Considering these factors, **Wi-Fi Low Power 802.11ah** emerges as a more suitable solution for camera data transmission. Wi-Fi operates in higher frequency bands (2.4GHz and 5GHz) and offers significantly higher data rates (up to 7.8Mbit/s), capable of handling VGA camera data transmission efficiently, whether at regular intervals or continuous streaming.

However, Wi-Fi's higher power consumption (from 10mW to 1W) compared to ZigBee (from 1mW to 100mW), which could impact battery life in battery operated devices. Despite this drawback, leveraging Wi-Fi for camera data transmission and ZigBee for monitoring parameters ensures an efficient and reliable monitoring solution for the bacterial cellulose factory's production process.