Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Robust and Highly Efficient Beamforming Procedures for 60GHz WPAN ~ Beam-Searching and -Tracking~]

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Re: [In response to TG3c comments (IEEE P802.15-08-0020-05-003c)]

Abstract: [Beam-searching and beam-tracking procedures are shown.]

Purpose: [To be considered in TG3C baseline document.]

Robust and Highly Efficient Beamforming Procedures for 60GHz WPAN ~Beam-Searching and -Tracking~

March 20, 2008

Summary

Robust and highly efficient beamforming procedure is proposed

Highlighted by

1. Monitoring current selected beam
2. Monitoring two adjacent beams to the current selected beam
3. **Monitoring the second best SNR beam**

Supported by

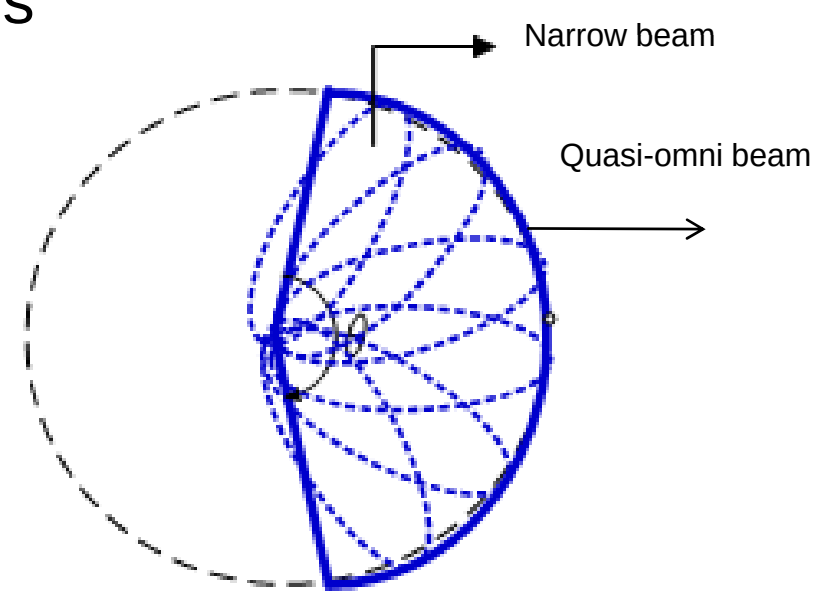
1. **Beam-searching:** Process to find the best beam
2. **Beam-tracking:** Process to monitor beam and switch to maintain optimal beam-forming performance
3. **Fast feedback signal transmission** by Quasi-Omni beam

Similarities to and Differences from Tensorcom's Beamforming (15-08-0182-00-003c)

- Similarities
  - *N* transmitter beams, *M* receiver beams
  - Search process
  - Code-book-assisted beamforming
  - Quasi-omni beam by multiple narrow beams
- Differences
  - Beam-tracking which monitors the second best SNR beam **for quick communication channel recovery against sudden interruption**
  - Beam-searching and -tracking supported with **fast feedback signal transmission by quasi-omni beam**

Beamforming Assumptions

- At least one end of the communication link (PNC/DEV) has a beamforming antenna
- Antenna pattern can be synthesized using a pre-defined beam pattern code book
  - Quasi-omni or wider beam can be obtained by combining narrow beams
- Only the PNC and DEV communications are considered
- The PNC is the transmitter with *N* narrow beams and DEV is the receiver with *M* narrow beams (following example *N*=8, *M*=8)



Narrow beams in quasi-omni beam

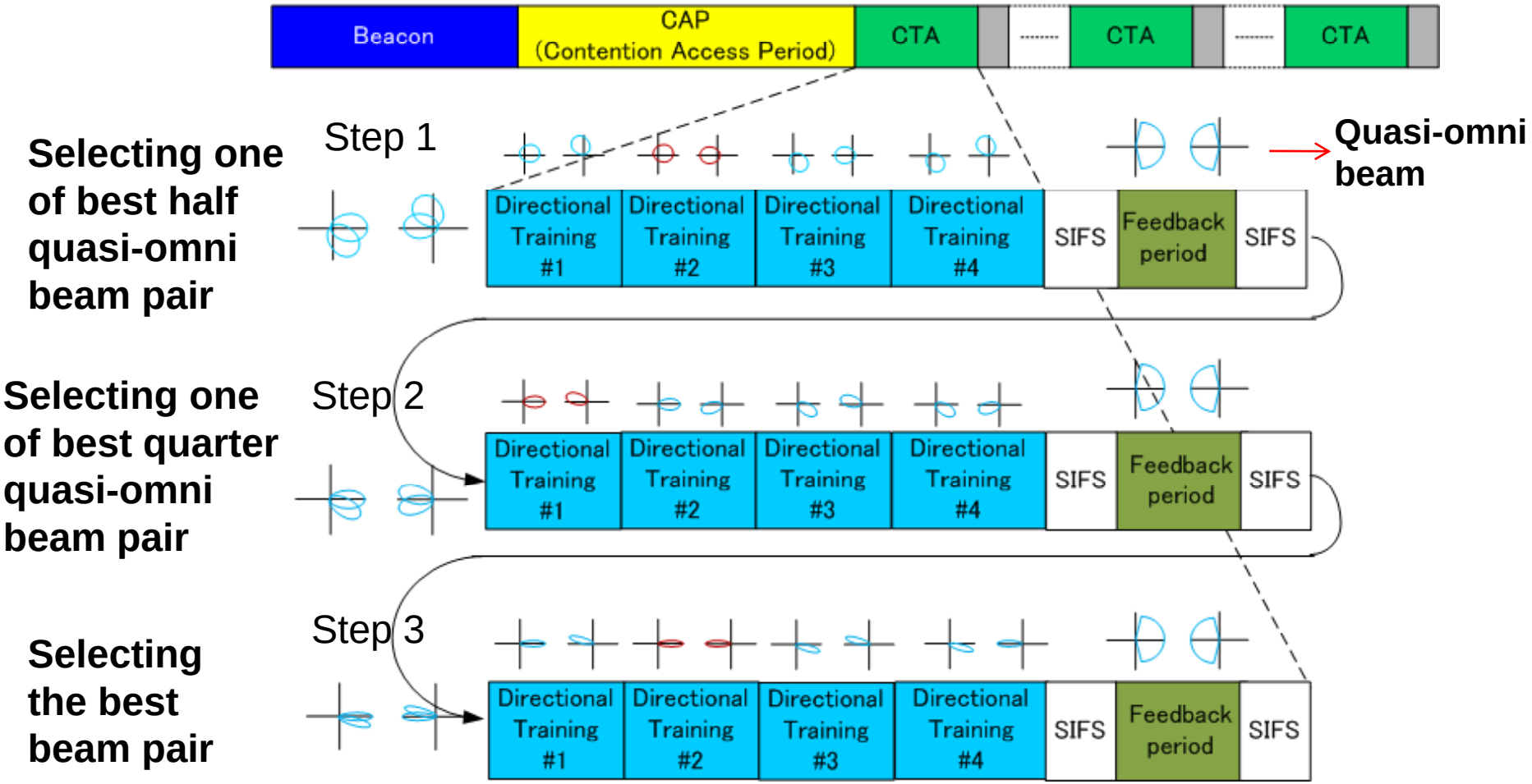
Beam-Searching Procedure (1/3)

- Beam-searching is performed in CTAP to find the best narrow beam pairs in the pre-defined beam pattern code book
- The best beam pair is defined as the beam pair between the transmitter and receiver which provides the largest possible SNR
- Beam training sequences shall be transmitted with narrow beam to detect the best narrow beam pair
- Feedback of the best beam indices shall be transmitted by using either quasi-omni or narrow beam
- Quasi-omni beam is recommended here since it can complete beam-searching in a shorter time

Beam-Searching Procedure (2/3)

- The beam-searching is conducted in CTA
- Beam-searching procedures
  1. The allocated CTA is divided into few sections (Each section ends with a feedback period in which the best beam indices and SNR are sent back to the PNC)
  2. Step1: Selecting one of best half quasi-omni beam pair out of 4 beam-direction combinations, resulting in 50% reduction of beam pattern candidates
  3. Step 2: Selecting one of best quarter quasi-omni beam pair, furthermore reducing 50% of the beam pattern candidates out of remaining ones
  4. Step 3: Selecting one of best narrow beam (final) pair
  5. After beam-searching, the SNR of each best pair shall be re-measured (connection through test)

Beam-Searching Procedure (3/3) - with Reduced Search Time -



Beam-Tracking Procedure (1/3)

- After the completion of beam-searching, PNC and DEV must keep communications with the best beam pair – beam-tracking
- Beam-tracking based on measured SNR with two thresholds: SNR1 and SNR2(> SNR1)
- If the measured SNR gets lower than SNR1 for a specific time, the system declares “beam-tracking lost”
- Then, switches to an adjacent beam or the second best SNR beam
- If the measured SNR is lower than SNR1 for all options for a specific time, then the system declares “beamforming lost”
- Then, the system gets into “beam-searching”
- If the measured SNR exceeds SNR2 for a specific time, the system declares “beam-searching complete” and gets into beam-tracking
- The proposed beam-tracking includes
  1. Monitoring current selected beam
  2. Monitoring two adjacent beams to the current selected beam
  3. Monitoring the second best SNR beam

Beam-Tracking Procedure (2/3)

(Tracking other possible beams)

1. Current (communications) beam
   - SNR measurement frequency (F_c): every superframe
2. Adjacent beams (Fig. a)
   - SNR measurement frequency (F_a): < F_c (ex. every 10 superframes)
3. The second best beam (Fig. b)
   - SNR measurement frequency (F_s): << F_c (ex. every 100 superframes)

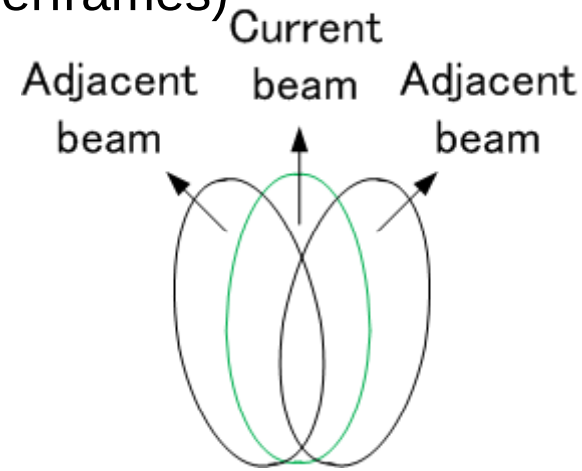


Fig. a

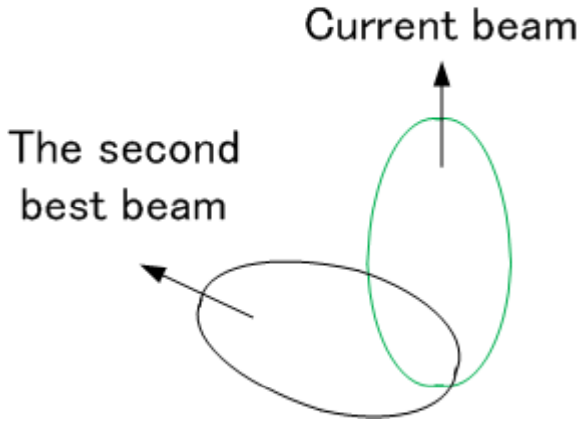
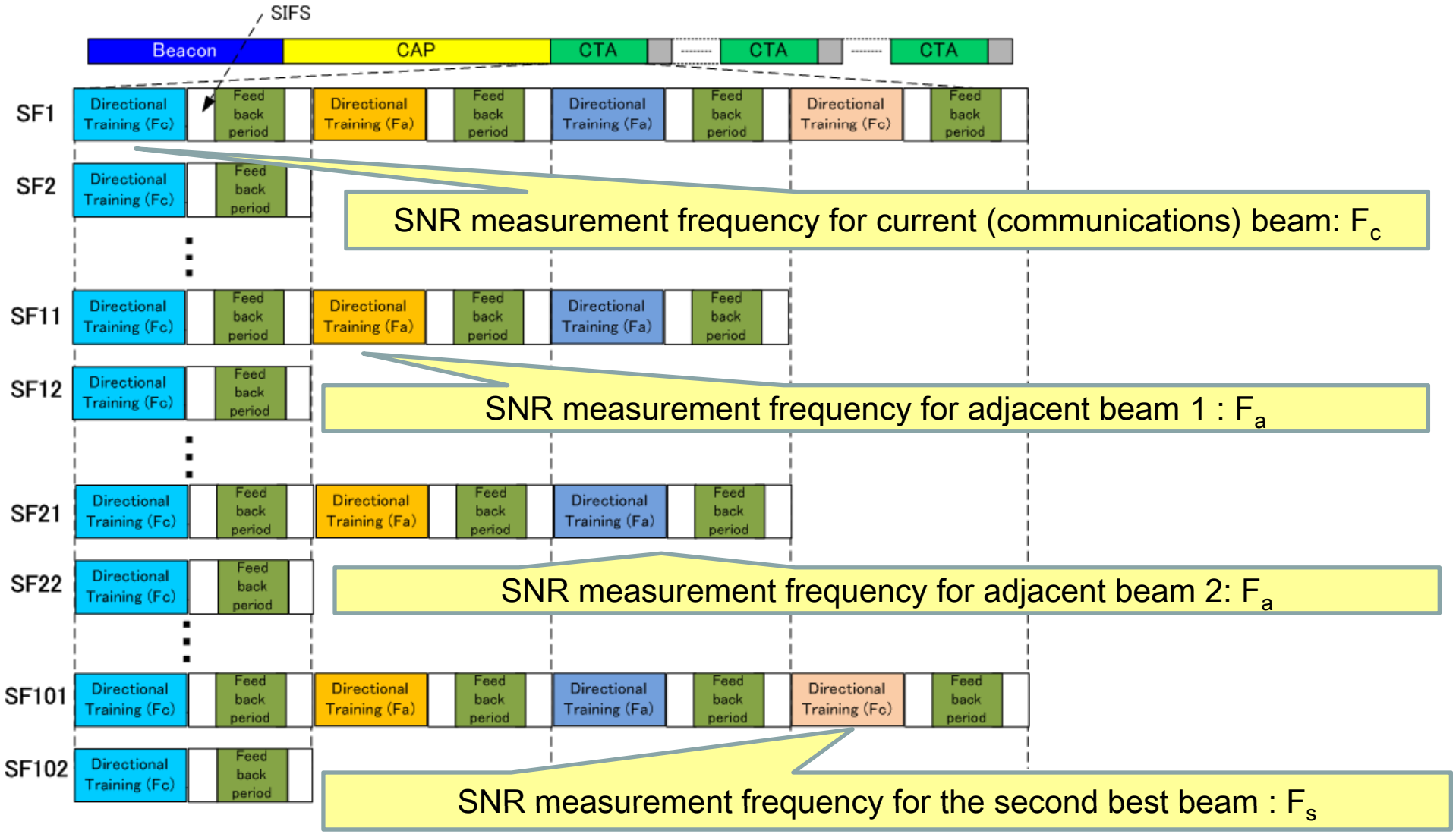


Fig. b

Beam-Tracking Procedure (3/3)



Conclusion

Robust and highly efficient beamforming procedure is proposed

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