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

Submission Title: [Some comments on merged draft from the viewpoint of the VL-ISC]
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Re: [Merged ETRI, Intel, Samsung, CSUS draft, document 15-09-0786-01-0007]

Abstract: [Give a comment on draft and related document from the viewpoint or ISC
(ISC: Image Sensor Communication)]

Purpose: [ ]

Some comments on merged draft from the viewpoint of the VL-ISC

(VL-ISC: Visible Light Image Sensor Communication)

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Contents

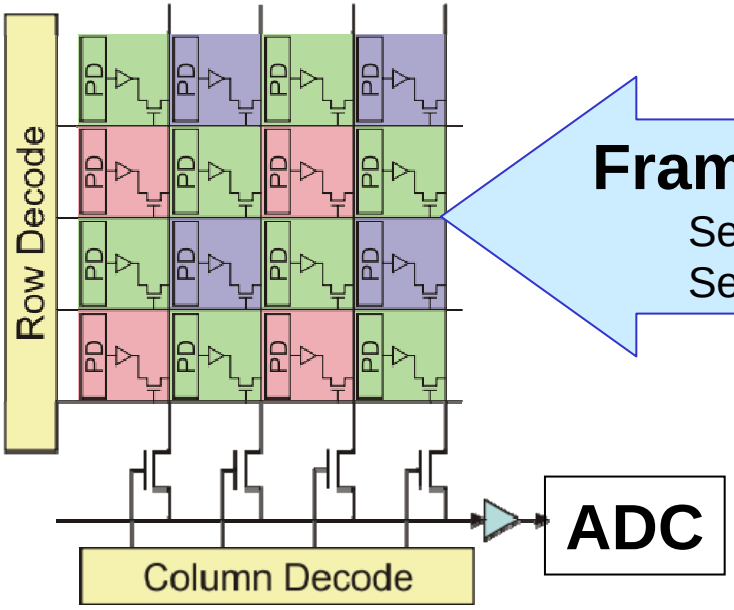
- Comments on important issue
  - **Proposal of the band security of optical rate with under 100kHz for ISC (Super low rate).**
- Comments on other issues (not so serious)
  - **Preamble for MAC operation code**
  - **PHY Header synchronization**
  - **ISC and CCM**

Modulation frequency (Optical rate) of ICS

- In document 15-09-0796-01-0007, 200KHz optical rate was defined as Low rate PHY
- However, defined 200KHz is too fast to implement for “normal Image Sensor” architecture. It means more than 200kfps.
  It is difficult to implement in short term even though we use "windowing" or other feature of CMOS Image sensor.
- We propose the **Super-Low frequency under 100KHz**
  - We think the frequency of several KHz to be enough as application with the marketability.
  - Anyway, we should consider this band for market realization of realistic ISC.

“Normal Image Sensor” architecture

- “Imaging capture” function is fast priority.
  - At any rate, ISC is able to provide new user experience combined with an image.
- The technology camera industry established is expanded to communication.



Frame capture cycle (Not so fast)
Several ten frames fps in Hi-resolution
Several thousands fps in very-low-resolution

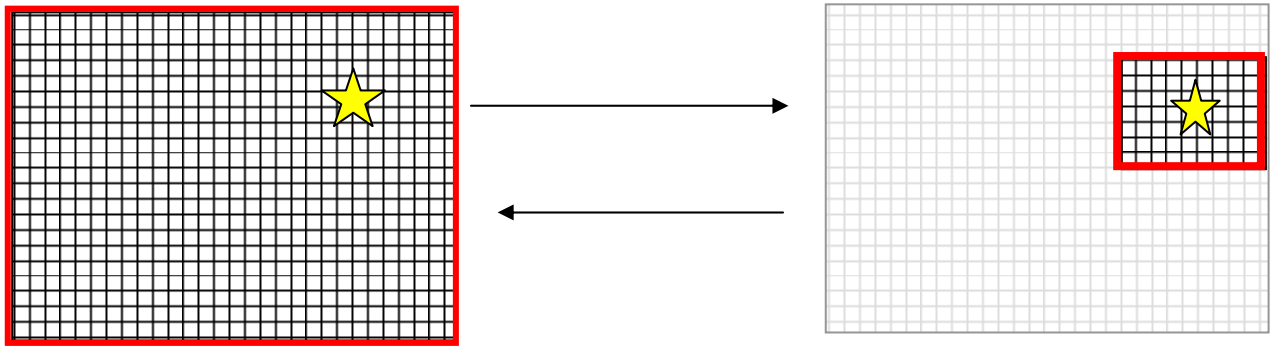
Wikipedia: CMOS_Image_Sensor_Mechanism_Illustration.svg

Windowing for fast frame per second

- Some CMOS image sensor has a feature of windowing. (We seem it also normal architecture)
- As for us, it is got a more expensive frame rate by windowing, but the current performance is thousands fps several tens square pixels.
- Of course it is effective that making a cheap-and-fast sensor with narrow FOV or low spacial-resolution from the beginning.

ex)1280x960pix 30fps

ex)40x30pix **5000fps**



Normal camera mode
Full frame size

Communication mode
(Windowing to fast capture)

Super low rate applications
(optical rate under 100KHz)

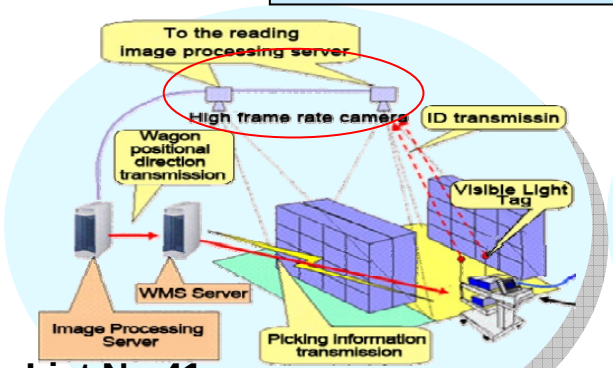
- The application that ISC becomes most suitable has a need to relate data and its positions.
  And in such case, position information(s) bring effective value more than bit rate.

- The data rate is not a number to guarantee the size of the market.
  For example, there is the GPS for the purpose of getting the information of the position.
  At that protocol “navigation message” data is transmitted only 50bps, but it forms a huge market.

- I believe that the possibility of ISC is very bigger than an impression from low data in the first phase.

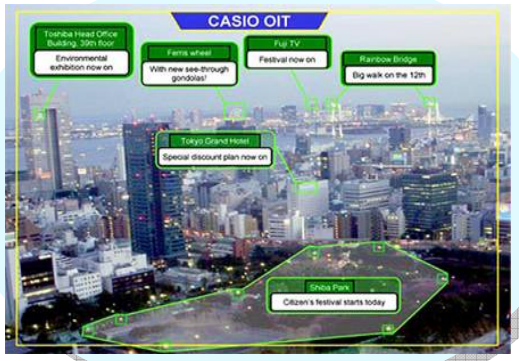
Many applications of ISC

Using spatial property in communication

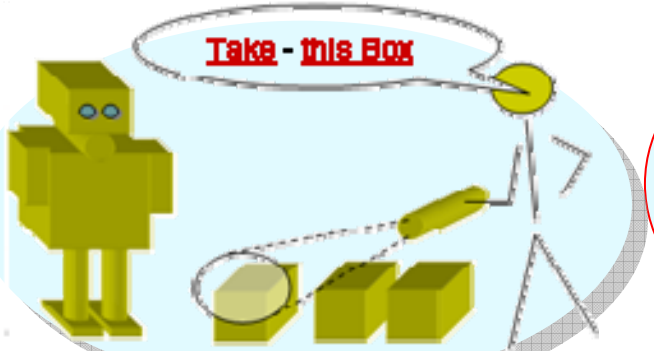


List No.41
Positional measurement at Factory and warehouse

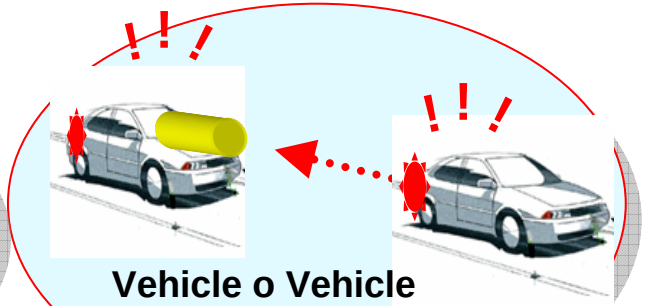
List No. 47
ITS Navigation



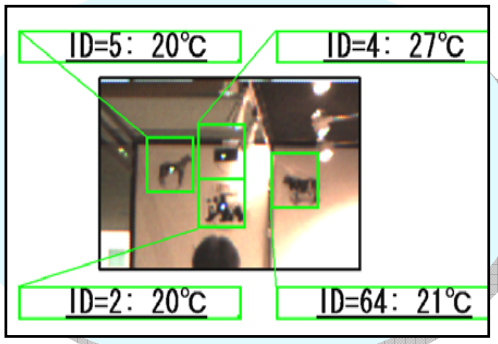
List No. 46
Guiding in spectacle outdoor



List No.43
Robotics (Indicate and command)



Vehicle o Vehicle
Pre crash safety



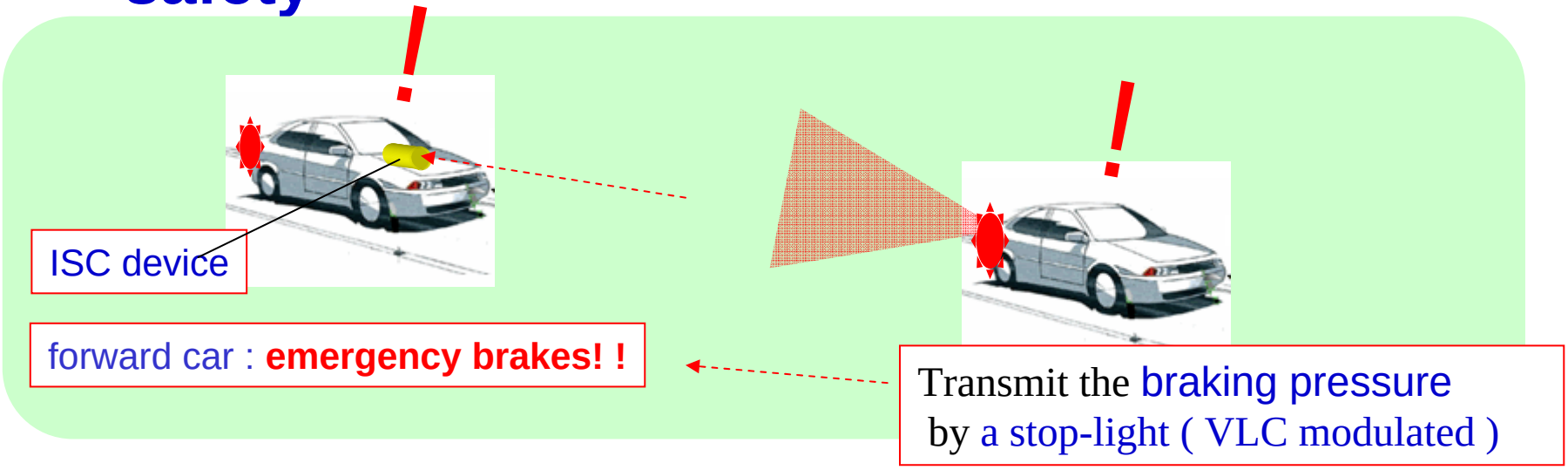
List No.40
Positional sensor net

Application summary list: doc.: 15-09-0125-08-0007-vlc-application-definitions-and-summary.xls

A test calculation for feasibility of "vehicle to vehicle ISC" in super low rate

Assumed application:

Vehicle to vehicle communication for "**Pre-crash safety**"



Based on the results of Japanese ISC developers (CASIO, NEC, TOSHIBA),
This test calculation shows it will **be enough at several thousands fps.**
Several thousands fps means using super low rate modulation frequency.

Why this application was assumed

- **Human reaction time is a problem in the security.**
  - Reaction time + motion time = **1.75 seconds** (worst case)...
  - In 1.75 s, a car of the **100km/h** speed runs for **49m**.
  - After human reaction, brake starts to work,100km/h speed needs **56m** to stop.
  - Total distance to stop = 49 + 56 =**105m**.

    This distance seems too long to stop before crash.

- We can transmit brakes information with any communication technology, but it is no use for reacting to a car behind or opposite lane.
- VLC with PD is seemed to have a difficult issue interference, distance and FOV, positioning
- Only for the presser strength of brakes, even 8bit length will be enough.

➔**ISC give the solution of these problems. Even though it is super low rate.**

Assumed specification and test calculation

- Image sensor
  - resolution: 640x480 pixel
  - Feature: Windowing control is valid in any part of area.
  - Frame rate / data rate:
    - Pixel read out rate: 46Mpix/s
    - Frame rate: 150fps@640x480(Full area),
      6100fps@100x80 (widowing area in communication)
    - Chip rate: 3.05K chip/s , Bit rate: 1.5Kbps (Assumed 64bit/block format, block receive cycle is 42ms/block)

- Optics and FOV
  - Device FOV (lens FOV): 20 degree (= approximate x2 zooming)
    3 degree (at windowing)
  - Pixel FOV = 20 / 640 = 0.031 degree
    - (0.031 degree => 0.05cm@1m/pixel, 5cm@100m/pixel)
  - Assumed stop lamp size=15cmx15cm, 3pixel@100m
  - The apparent diameter of the stop lamp of the 100m is bigger than Pixel-FOV. **FOV is OK.**

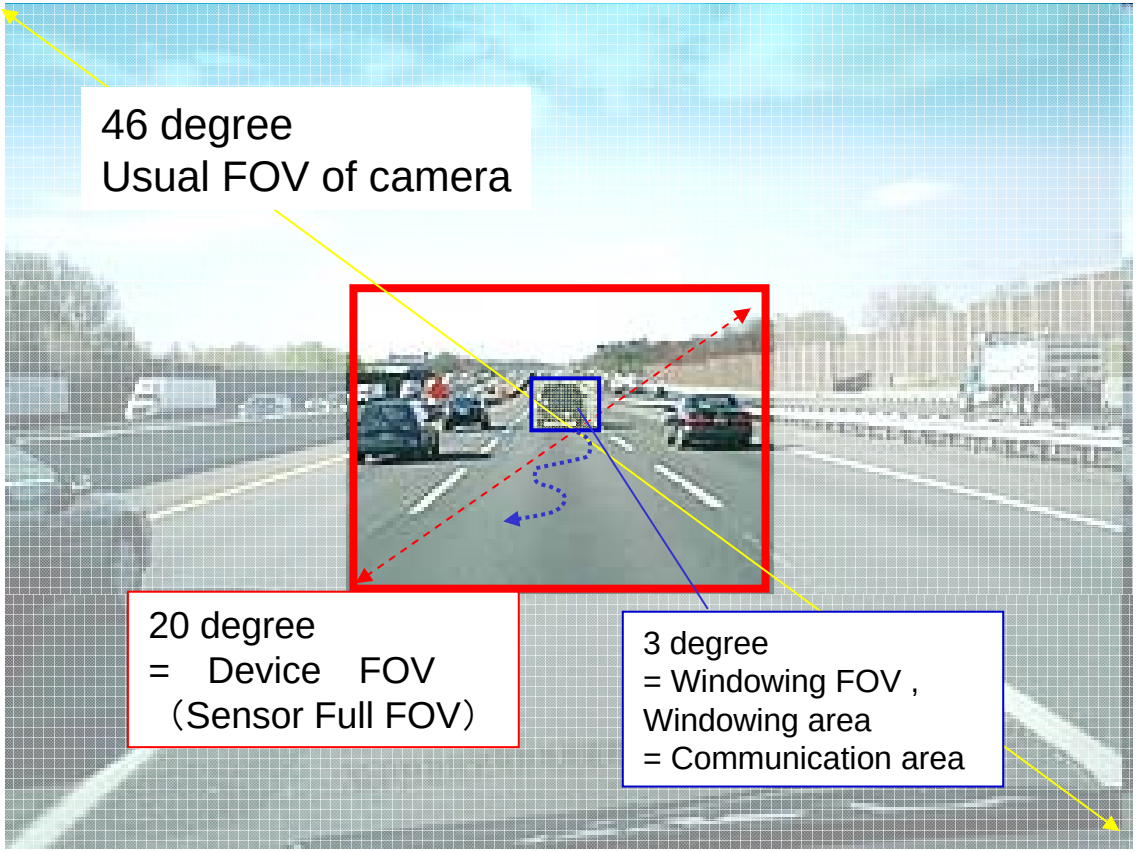
- MAC and PHY
  - OOK, I-4PPM , PN-code header is added to the payload ・・・・・
  - Almost same to the format descried in IEEE doc:802.15<09-0659-00-0007>

- Discovery and Tracking
  - Assumption about discovery: **0.2s**
    - It supposed that image processing is used for "windowing area decision" .
    - Time for windowing area decision 0.15s, (worst case)
    - Delay time of first valid receiving after stop lamp lightning 0.05s
  - Assumption about Tracking:
    There are movements in image for various factors, but we think it can be adapted successfully..

Result of the test calculation

- If we use ISC in pre-crash safety....
  - Human response time: 1.75s worst
  - ISC response time : 0.2s worst
    - And it reacts to only the car of precise position relations.
  - **It was able to secure the time of safe margin of 1.5s.**
    - 1.5s is equal in distance to , 42m@100km/s, 64m@150km/h.

ISC of even several thousand fps can provides these performance.



To decide for “Windowing area” position,
"car object recognition" or "the center line recognition“ should be used together.

Comments of other issue

- **Preamble for MAC operation code**
- **PHY Header synchronization**
- **ISC and CCM**

6.4.2 Table21
Preamble for MAC operation code

- However, I firmly believe that there is a unknown effective feature of MAC (not only for topology) might appear.
  So, I would like to propose Px should be reserved for future extension.

6.4.2 PHY Header synchronization

- Following expression is described in this section

  …**all light sources shall transmit the same preamble simultaneously.** ……

- At the viewpoint of ISC, It seems to be unnecessary severe limitation .
  - Many light sources are completely divided if we use the image array, because of spatial separation capability of ISC.
  - Therefore we may not mind synchronization of each light source.

- Following expression is complete from the viewpoint of ISC
  - **When space separation is not guaranteed by image Array,** all light sources shall transmit the same preamble simultaneously.

6.6.3 High data rate and CCM PHY specifications

- ISC is not strong in high speed. On the other hand, many image sensors are colorized by a color filter.
- Therefore, even the PHY of the low speed (for ISC) should use CCM in ISC in particular positively.
- It will still need many studies and arguments to apply CCM to ISC.
  However, we should use CCM for the speedup positively.