Energy Efficiency for ISAAC

IEEE 802.3

ISAAC Study Group

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Background

- In last several years, most (if not all) Base-T and Base-T1 projects have had an objective to support optional "Energy Efficient Ethernet" or EEE
- EEE involves several aspects
  - Provision for TX side to go in lower power state
  - Option for RX side to go in lower power state as a result of corresponding TX side going into lower power state
  - LPI signaling between LPI Client, RS and PHY
  - Sleep, Refresh, wake timers
- EEE as currently defined does not assume any pre-determined traffic pattern
  - Initiates energy saving mode depending on layer 2 signal to Physical layer
- If a system can handle random traffic, it can certainly handle pre-determined traffic pattern (any pre-determined pattern is a subset of randomness)
- In camera applications, the patterns are generally fixed or known ahead of time
- ISAAC can make use of this aspect to save energy and should include an objective for energy efficient operation
- Potential enhancements/changes to existing EEE framework to facilitate pre-determined traffic patterns is a good topic for ISAAC (a brand new framework is likely not needed).

Camera Usage Scenarios – Payload Vs PHY Speed

- The table below shows payload bandwidth calculation for very commonly used cameras
- Conventional overhead factor of 1.1x is used for BW calculations
- It should be noted that the conventional usage typically does not include some overhead such as security
- The table below contains both - conventional and additional overhead scenarios

Resolution (MP)	Frames/sec	Bits per pixel	Conventional Overhead factor	Other overhead (e.g. security)	BW Needed (Gbps)	PHY needed	
8	30	16	1.1	1	4.224	5G	
8	30	20	1.1	1.1	5.808	10G	Inefficient
5	30	16	1.1	1	2.64	5G	Inefficient
5	30	16	1.1	1.1	2.904	5G	Inefficient
2	30	16	1.1	1	1.056	2.5G	Inefficient
2	30	16	1.1	1.1	1.1616	2.5G	Inefficient

- It can be seen how the payload bandwidth differs from the max data rate that the PHY is capable of
- Link utilization can end up being highly inefficient in many cases

Relative Power Analysis – Nominal Case

- The table below is meant for generic PHY power profile in down stream and upstream directions
- The power of Downstream TX is used as a baseline for relative power of other blocks – represented as "100" units
- This table is not representing absolute power in watts
- The numbers below are for nominal operation at full load (no energy efficiency)

	Nominal Operation	Relative Power
A	Downstream TX @ 10G	100
B	Downstream RX @ 10G	160
C	Up stream TX @ 100M	30
D	Up stream RX @ 100M	40
A+D	Total Camera side power	140
B+C	Total SoC side Power	190

Power Efficiency for 60% loaded DS link

The table below is representing a PHY operating at 60% payload in downstream direction and 1Mb in the upstream direction

- 20% power saving is modeled for 40% reduction in payload
- 50% power saving for modeled for 99% reduction in payload

	Power Efficient Operation	**6G down, 1M up**	**Modeled Scenario**
A	Downstream TX @ 6G	80	20% saving for 40% reduction in payload
B	Downstream RX @ 6G	128	20% saving for 40% reduction in payload
C	Up stream TX @ 1M	15	50% saving for 99% reduction in payload
D	Up stream RX @ 1M	20	50% saving for 99% reduction in payload
A+D	Total camera power	100	
B+C	Total SoC side Power	143	
	% power savings for Camera	**29%**	
	% power savings for SoC side	**25%**	

Conclusions

- Many camera usage scenarios will result in non-optimal link utilization
- Energy saving mechanism based on known usage patterns makes system more efficient
- Meaningful amount of power reduction can be achieved for both camera and SoC sides
- Power (and heat) reduction is a very important aspect of automotive systems
- Therefore, ISAAC should include a specific objective for energy efficient operation
- Potential enhancements/changes to existing EEE framework to facilitate efficient operation of pre-determined traffic patterns is a good topic for ISAAC

Thank You!