Unapproved Minutes

IEEE P802.3 100 Gb/s Electrical Lane Study Group

Interim Meeting

January 25-26, 2017

Geneva, Switzerland

Prepared by Kent Lusted

(minor assist by Adee Ran and Beth Kochuparambil)

Table of Contents

IEEE P802.3 100 Gb/s Electrical Lane Study Group – January 25, 2018

Prepared by Kent Lusted

IEEE P802.3 100 Gb/s Electrical Lane Study Group meeting convened at ~1:05 p.m., by David Law, IEEE 802.3 Working Group Chair.

Mr. Law welcomed attendees.

David Law appointed Kent Lusted to be the recording secretary for the IEEE 802.3 100 Gb/s Electrical Lane Study Group.

Motion #1:
Confirm Beth Kochuparambil as the IEEE 802.3 100 Gb/s per Lane Electrical Study Group Chair.

- Moved by: Brad Booth
- Second by: Thananya Baldwin
- Y: 54 N: 0 A: 0
- Motion passes!

Beth Kochuparambil assumed the Chair of the Study Group.

Introductions were made. Chair appointed Kent Lusted to be the Vice Chair of the Study Group.

Chair reviewed agenda in
http://www.ieee802.org/3/100GEL/public/18_01/agenda_100GEL_01b_0118.pdf

Motion #2:
Move to approve the agenda:

- Moved by: Thananya Baldwin
- Second by: Adee Ran
- Passed by voice without opposition

Chair reminded participants to observe meeting decorum. Called for members of the press. No one indicated. Photography and recording are not permitted.

Chair reviewed the ground rules for the meeting.

Chair reviewed the attendance procedures. Chair reminded participants to sign into the IEEE Meeting Attendance Tool and to sign the book.

Chair reviewed the IEEE structure.

Chair reviewed the Bylaws and Rules slides in
http://www.ieee802.org/3/100GEL/public/18_01/agenda_100GEL_01b_0118.pdf

Chair asked if there was anyone unfamiliar with the Bylaws or Rules. No one responded.

Reviewed the guidelines.

Reviewed the reflector and web information for the Study Group in the agenda deck.

Chair provided a summary of the study group status.

Chair reviewed the IEEE 802.3 Standards Process.

Chair reviewed the study group ad hocs that occurred before the interim meeting. The ad hoc material is located at: http://www.ieee802.org/3/100GEL/public/adhoc/index.html

Chair reviewed two possible timelines for approvals to transition to a Task Force. She noted the 2 paths to Task Force: May 2018 or November 2018. This is due to the approval cycle. A straw poll on the ad hoc call indicated support for a Task Force in May 2018. Chair asked for a show of hands opposed to the goal of transition to Task Force in May 2018. There was some concern from participants about reaching consensus in that schedule, but not speaking in opposition.

Goals for the meeting:

- Completed PAR
- Completed CSD responses
- Adopt Objective forms

Chair noted that she received a liaison letter from the OIF. See:
http://www.ieee802.org/3/minutes/jan18/incoming/OIF_to_IEEE_802d3_112G_Jan_2018.pdf

Chair asked if there was opposition to deferring the response to OIF until the March Plenary meeting. There was discussion if it should be deferred or written at the current meeting. Chair asked participants to review the OIF liaison and stated that the Study Group will make a determination after the break.

Chair reviewed the meeting and presentation schedule.

There was a question on CSD and PARs with respect to Working Group approval.

George Zimmerman noted that his presentation could be omitted in the interest of time. Chair thanked George.

Presentation #1:
"Study Group Crash Course", Mark Nowell
See: http://www.ieee802.org/3/100GEL/public/18_01/nowell_100GEL_01_0118.pdf

- Author advised the participants to focus on the supporting material for the PAR/CSD and avoid going into detail.

Chair noted there was a late contribution from Tom Palkert regarding Broad Market Potential of cables. Chair asked if there was objection to posting it. No one responded.

Presentation #2:
"100 Gb/s Electrical Links System View", David Ofelt
See: http://www.ieee802.org/3/100GEL/public/18_01/ofelt_100GEL_01_0118.pdf

- There was concern that C2M AUI will be harder due to complexity and limitations of the module and channel loss.
- Discussed the possibility of having different PHY types or retimers in the path and not a one-size-fits-all solution for all the PHY types in the project.
- It was noted that the reach and insertion loss impact of 100 Gb/s per lane will present a new set of scaling problems not encountered recently.
- Discussed the tradeoffs of power, area, cost impact on a system architecture.

Presentation #3:
"Architectural Consideration for 100 Gb/s/lane Systems", Ali Ghiasi
See: http://www.ieee802.org/3/100GEL/public/18_01/ghiasi_100GEL_01a_0118.pdf

- Author had an updated version '01a' with a clarifying note. Chair asked if there was objection to hearing the updated presentation. There was no opposition.
- Discussed some of the characteristics of the PCB materials on slide 12.
- Discussed a 30mm package without PTH that had a loss of 6 dB @ Nyquist and that 4 dB is a best case.
- Discussed the system impact of a host with a mix of Type I and Type II ports noted on slide 2.

Chair reminded attendees to sign into the IEEE Meeting Attendance Tool and to sign the attendance sheets.

Break at ~3:10 p.m. Resumed ~3:30 p.m.

Chair noted that the term “per lane” was being discussed at the Working Group level and the definition has been contentious. Therefore, the term has been purposely avoided in the project documentation, but used with “fuzzy” definition (lane means different things to different people) for objectives and scope rulings. If there is concern, please contact the Chair or Vice-Chair offline.

Chair asked that feedback on the PAR and CSD focus on the major elements that may be missing. Please send editorial corrections and requests via email to the Chair and Vice Chair.

Presentation #4:
“Proposed CSD Language”, Kent Lusted
See: http://www.ieee802.org/3/100GEL/public/18_01/lusted_100GEL_01a_0118.pdf

- Received feedback on proven and existing media. Considered adding new media reference.

Presentation #5:
“Proposed PAR Language”, Beth Kochuparambil
See: http://www.ieee802.org/3/100GEL/public/18_01/kochuparambil_100GEL_01a_0118.pdf

- It was noted that if SERDES is used in section 5.5, expand the definition in the PAR section 5.1.
- It was noted that a change of the BER of an optical PHY would not be allowed by the scope of the project as written in ‘01a’.
- Discussed several examples that would require a PAR modification or a CFI.
- Discussed the consideration of segmented FEC to meet potential objectives.

Chair noted that the term “per lane” was being discussed at the Working Group level and the 802.3cj Revision project. The current definition of “lane” has been contentious and means different things to different people. Therefore, the term has been consciously avoided in the project documentation. Chair ruled that the presentation http://www.ieee802.org/3/100GEL/public/18_01/farjadrad_100GEL_01a_0118.pdf that has a bi-directional proposal is within scope.

Presentation #6:
“Initial thoughts on 100Gb/s per lane AUI Objectives”, Gary Nicholl
See: http://www.ieee802.org/3/100GEL/public/18_01/nicholl_100GEL_01a_0118.pdf

- Discussed the potential objective forms for the AUI objectives on slide 7.
- There was a suggestion to defer the technical details of the objective to the Task Force.
- There was a suggestion to remove the “compatibility” part of the AUI C2M objective.
- Discussed the impact of segmented FEC on the AUI objective wording.

Chair asked participants to continue to review the proposed objectives and wording in preparation of discussion tomorrow.

Chair noted that she is seeking guidance from the Study Group on the areas needing consensus on objectives and prepared a series of straw polls.

There was discussion of Straw Poll #1. It was noted that there were no 200 Gb/s optical PHYs today that use 100 Gb/s optical signaling. There was a suggestion to decouple the 100 Gb/s electrical signaling rate from the MAC rates listed in the PAR.

Straw Poll #1:

	I would support some objectives being adopted for:	I would oppose any objectives being adopted for:	I am unsure about objectives being adopted for:
100 Gb/s Ethernet	53	0	1
200 Gb/s Ethernet	45	0	10
400 Gb/s Ethernet	53	0	5

Straw Poll #2:

100 Gb/s	I would support an objective being adopted for:	I would oppose an objective being adopted for:	I am unsure about an objective being adopted for:
C2M	58	0	0
C2C	39	1	13
Backplane	31	0	21
Twinax cable	24	0	27

Straw Poll #3:

200 Gb/s	I would support an objective being adopted for:	I would oppose an objective being adopted for:	I am unsure about an objective being adopted for:
C2M	40	1	6
C2C	24	1	23
Backplane	26	0	24
Twinax cable	17	0	27

Straw Poll #4:

400 Gb/s	I would support an objective being adopted for:	I would oppose an objective being adopted for:	I am unsure about an objective being adopted for:
C2M	51	0	0
C2C	31	1	20
Backplane	30	0	21
Twinax cable	18	0	30

Chair summarized the results and highlighted areas that need contributions and consensus building.

Chair announced a start time on Friday of 8:00 a.m.

Chair reminded participants to sign into IMAT and to sign the attendance book.

Chair asked, by show of hands, if there was opposition to tabeling OIF liaison response to March Plenary given that OIF next meets face-to-face in April. No hands were raised.

Break for the day at ~5:30 p.m.

IEEE P802.3 100 Gb/s Electrical Lane Study Group – January 26, 2018

Prepared by Kent Lusted, Adee Ran, and Beth Kochuparambil

Meeting convened at ~8:05 a.m. by Beth Kochuparambil, IEEE 100 Gb/s Electrical Lane Study Group Chair.

Chair outlined the plans for the day. Asked participants to review the CSD responses and PAR responses. The goal for the day was to approve the PAR and the CSD for pre-submittal to the IEEE 802 EC.

Chair asked participants to consider straw polls for the Study Group.

Chair reminded participants to sign into the IEEE Meeting Attendance Tool and the attendance book.

Presentation #7:
"OIF to IEEE 802.3 on OIF CEI-112G projects", Mike Li
See:
http://www.ieee802.org/3/minutes/jan18/incoming/OIF_to_IEEE_802d3_112G_Jan_2018.pdf

- Discussed the BER target of 1E-15 for the CEI-112G-LR. It was noted that OIF 112G VSR and MR have a BER target of 1E-5.
- The OIF project start does not specify the modulation scheme.

Chair asked Mike Li and Nathan Tracy to prepare a liaison response to OIF for the March plenary meeting.

Chair reminded participants to sign into the IEEE Meeting Attendance Tool and the attendance book.

Presentation #8:
"100G / Lane Electrical Interfaces for Datacenter Switching", Rob Stone
See: http://www.ieee802.org/3/100GEL/public/18_01/stone_100GEL_01_0118.pdf

- It was noted that the green area around the switch ASIC on slide 7 was covered by the heatsink.
- Reviewed the end user wants listed on slide 3 and it was noted that each customer tends to have a different priority.

- Discussed the trace length estimates give on slide 7.
- Discussed the need for the short reach interface in advance of the longer reach copper and backplane PHYs.
- Discussed the impact of retimers on the system.
- Discussed the channel reach on the PCB for a mid-board optical solution.
- Discussed the impact of lower-loss materials on the system electrical signal integrity and cost.

Chair asked participants to consider straw polls for the Study Group.

Presentation #9:
"Measured Data for 112G Chip to Module Channel Analysis", Nathan Tracy
See: http://www.ieee802.org/3/100GEL/public/18_01/tracy_100GEL_01a_0118.pdf

- The host and module board uses Megtron 7N material.
- Discussed the channel results on slide 6 and slide 7. It was noted that the variation observed at higher frequency is related to the breakout at the connector.

Presentation #10:
"System impacts of CR variant", Tom Palkert
See: http://www.ieee802.org/3/100GEL/public/18_01/palkert_100GEL_01_0118.pdf

- Clarifying questions were asked and answered.

Presentation #11:
"Considerations for 100 Gb/lane Electrical Interfaces", Chris Diminico
See: http://www.ieee802.org/3/100GEL/public/18_01/diminico_100GEL_01a_0118.pdf

- Discussed the loss per inch assumptions as it relates to the trace routing on the test boards.
- Reviewed the loss allocations on slide 7 (link budget). It was noted that the NIC host PCB trace loss included the connector loss. The BiPass cable loss includes the whole assembly.
- There was concern on the high volume viability of connectors.

Presentation #12:
"Considerations for 100 Gb/lane Electrical Interfaces", Chris Diminico
See: http://www.ieee802.org/3/100GEL/public/18_01/diminico_100GEL_01a_0118.pdf

- The channel is the mated compliance boards for a QSFP-DD set. No xtalk was used.

- Discussed that the COM values were estimates and need further exploration.
- On slide 14, the 9 inch length includes the traces inside the connector.
- It was noted that the fixtures are commercially available now.

Break at ~10:20 a.m. Resumed at ~10:40 a.m.

Presentation #13:
"Host backplane channel models", Howard Heck
See: http://www.ieee802.org/3/100GEL/public/18_01/heck_100GEL_01_0118.pdf

- Clarifying questions were asked and answered.

Presentation #14:
"Channel Simulations for 112G Backplane Analysis", Nathan Tracy
See: http://www.ieee802.org/3/100GEL/public/18_01/tracy_100GEL_03_0118.pdf

- Author noted that slide 9 should have 100 Gbps not 112 Gbps.

Chair noted that the presentation from Toshi Sakai were condensed into a single presentation sakai_100GEL_01b_0118 that contains a summary. Chair asked if there was objection to hearing it. No one responded.

Presentation #15:
"Technical Feasibility of 100Gb/s per lane SerDes for Backplanes", Toshiaki Sakai
See: http://www.ieee802.org/3/100GEL/public/18_01/sakai_100GEL_01b_0118.pdf

- Discussed the simulation summary and details.
- Discussed the time-based simulation

Presentation #16:
"An Alternative Proposal to Maximize 100Gbps/Lane Electrical Link Performance", Ramin Farjadrad
See: http://www.ieee802.org/3/100GEL/public/18_01/farjadrad_100GEL_01c_0118.pdf

- Reviewed the dual duplex architecture on slide 13. It was noted that linearity needs to be better than a single duplex solution.
- The proposal could use a magnetic transformer, if necessary.
- Discussed compatibility with optical modules.
- The proposal assumes loop timing to achieve the benefits of the NEXT cancellers.
- Discussed the impact to area and power using the proposed solution.

Chair asked for a show of hands for another presentation before lunch. Most of the room indicated opposition.

Break at ~12:25 p.m. Resumed at ~1:20 p.m.

Meeting resumed at 1:16 p.m.

Presentation #17:
"100Gb/s Single-lane SERDES Discussion", Phil Sun
See: http://www.ieee802.org/3/100GEL/public/18_01/sun_100GEL_01b_0118.pdf

- Discussed impact to backward compatibility and complexity. The proposal considers that TX architecture might have to change
- Presentor indicates that system level impacts need to be considered
- Discussed TX SNDR modeling used and peak-to-average power
- Discussed self-contained vs section of link leading to splitting the backplane - opposition for splitting was voiced pointing back at PAM4 and NRZ of 25G
- Questions were asked about resolution of coefficients for taps and transmitter compliance testing, and putting this in the standard to enable interoperability.
- Concern was raised about trading off Tx and Rx complexity especially for C2M

Chair asked for opposition for seeing late presentation palkert_100GE_02_0118.pdf. No opposition was voiced by the floor.

Presentation #18:
"Broad Market Potential of 100G Copper Cable", Tom Palkert
See: http://www.ieee802.org/3/100GEL/public/18_01/palkert_100GEL_02_0118.pdf

- Discussion of data center architecture
- Discussion of manufacturability of loss numbers shown in the presentation

Chair reviewed the remaining items for the day and the impact of not approving the PAR and CSD at this meeting.

Break at ~2:10 p.m. Resumed at ~2:45 p.m.

Chair reminded participants to sign into IMAT and sign the attendance book.

Motion #3:
Move to adopt the following objectives:

  - Support a MAC data rate of 100 Gb/s, 200 Gb/s and 400 Gb/s
  - Support full-duplex operation only
  - Preserve the Ethernet frame format utilizing the Ethernet MAC
  - Preserve minimum and maximum FrameSize of current IEEE 802.3 standard
  - Support the existing bit error ratios (BERs) at the MAC/PLS service interface (or the frame loss ratio equivalent) for 100 Gb/s, 200 Gb/s and 400 Gb/s Ethernet

- M: Mark Nowell

- S: Brad Booth
- Technical (>=75%),
- Y:50 , N: 0, A:4
- Results: passes 2:52 p.m.

Straw Poll #5:
I would support adoption of the following objective:
    - Define a single-lane 100 Gb/s PHY for operation over electrical backplanes supporting an insertion loss <= TBD dB at TBD GHz
- Yes: 43, No: 0, Abstain: 8

Straw Poll #6:
I would support adoption of the following objective:
    - Define a single-lane 100 Gb/s PHY for operation over passive twin-axial copper cable with lengths up to at least TBD m.
- Yes: 33, No: 2, Abstain: 18

Motion #4: -
Move to adopt the following objective:
    - Define a single-lane 100 Gb/s Attachment Unit interface (AUI) for chip-to-module applications, compatible with PMDs based on 100 Gb/s per lane optical signaling
- M: Tom Palkert
- S: Rob Stone
- Technical (>=75%),
- Y: 54, N: 0 , A: 1
- Results: passes 3:38pm

Motion #5:
Move to adopt the following objectives:
    - Define a single-lane 100 Gb/s PHY for operation over electrical backplanes supporting an insertion loss <= TBD dB at TBD GHz.
    - Define a single-lane 100 Gb/s PHY for operation over twin-axial copper cables with lengths up to at least TBD m.
- M: Tom Palkert
- S: Adee Ran
- Technical (>=75%),
- Y:40 , N: 0 , A: 13

- Results: passes 3:51pm

Break at ~3:55 p.m. Resumed at ~4:15 p.m.

Motion #6:
Move to adopt the following objective:
    - Define a single-lane 100 Gb/s Attachment Unit Interface (AUI) for chip-to-chip applications
- M: Mike Li
- S: Pavel Zivny
- Technical (>=75%),
- Y: 43 N: 1   A:10
- Results: passes 4:25pm

Reviewed the proposed CSD responses in the lusted_100GEL_01a_0118. Changes were made from the floor to the CSD responses and saved as lusted_100GEL_01b_0118.

Motion #7:
Move to:
    - adopt the CSD responses for “Managed Objects”, “Coexistence”, “Broad Market Potential”, “Compatibility”, “Distinct Identity”, “Technical Feasibility” and “Economic Feasibility” as written in lusted_100GEL_01b_0118.pdf
- M: Mark Nowell
- S: Mike Dudek
- Technical (>=75%),
- Y: 47   N: 0   A: 1
- Results: passes!

Chair reviewed the proposed responses to the PAR. She noted the changes received offline. Discussion and modification arose from the floor. Changes were made and saved as kochuparambil_100GEL_01b_0118.pdf

Motion #8:
Move to:
    - adopt the proposed responses to the PAR as shown in kochuparambil_100GEL_01b_0118.pdf
- M: Robert Lingle

- S: Gary Nicholl
- Technical (>=75%),
- Y:42, N: 0 , A: 0
- Results: passes 6:06 pm

Chair prepared the PAR form on the IEEE website. David Law gave an overview of the responses in Section 6 and Section 7. Chair saved the file as P802_3ck_PAR_Detail.pdf

Chair reviewed future meetings and announced the next series of ad hocs over the reflector.

Motion #9:
Move to adopt the following objectives:

- Define a two-lane 200 Gb/s Attachment Unit interface (AUI) for chip-to-module applications, compatible with PMDs based on 100 Gb/s per lane optical signaling.
- Define a four-lane 400 Gb/s Attachment Unit interface (AUI) for chip-to-module applications, compatible with PMDs based on 100 Gb/s per lane optical signaling.
- Define a two-lane 200 Gb/s Attachment Unit Interface (AUI) for chip-to-chip applications.
- Define a four-lane 400 Gb/s Attachment Unit Interface (AUI) for chip-to-chip applications.
- Define a two-lane 200 Gb/s PHY for operation over electrical backplanes supporting an insertion loss <= TBD dB at TBD GHz.
- Define a four-lane 400 Gb/s PHY for operation over electrical backplanes supporting an insertion loss <= TBD dB at TBD GHz.
- Define a two-lane 200 Gb/s PHY for operation over twin-axial copper cables with lengths up to at least TBD m.
- Define a four-lane 400 Gb/s PHY for operation over twin-axial copper cables with lengths up to at least TBD m.

- M: Tom Palkert
- S: Mark Nowell
- Technical (>=75%),
- Y: 30 , N: 0 , A: 1
- Results: Passes 6:30 pm

Motion #10:
Move to Adjourn:

- Moved by: Mike Dudek
- Second by: Dave Ofelt
- Passed by voice vote without opposition

Meeting ended at ~6:35 p.m.

Attendees

100G/lane Electrical Lane Study Group, January 2018			25-Jan-18	26-Jan-18
Last Name	First Name	Affiliation	Thursday	Friday
Ahmad	Bilal	Huawei	x	
Anslow	Pete	Ciena Corporation	x	x
Baden	Eric	Broadcom	x	x
Baldwin	Thananya	Ixia	x	x
Ben Artsi	Liav	Marvell Semiconductor	x	
Bhatt	Vipul	Finisar	x	x
Booth	Brad	Microsoft	x	x
Braun	Ralf-Peter	Deutsche Telekom	x	x
Brown	Matt	MACOM	x	x
Butter	Adrian	Global Foundries		x
Calvin	John	VTM	x	x
Chang	Frank	Inphi	x	x
Chen	C. C. David	Applied Optoelectronics	x	x
Dawe	Piers	Mellanox	x	x

DeBarnardinis	Fernando	Marvell Semiconductor	x	x
DeGebst	Jan	Amphenol		x
DiMinico	Christopher	MC Communications/Panduit		x
Dudek	Mike	Cavium	x	x
Engbretson	Mike	GRL	x	x
Estes	Dave	Spirent Communications	x	x
Ewen	John	Global Foundries	x	x
Farjad	Ramin	Aquantia		x
Ghiasi	Ali	Ghiasi Quantum, Huawei	x	x
Gorshe	Steve	microsemi	x	
Graber	Steffen	Pepperl+Fuchs		x
Gustlin	Mark	Xilinx	x	x
Hajduczenia	Marek	Bright House Networks	x	
Harwood	Mike	HSZ Consulting	x	x
Hayakawa	Akinori	Fujitsu Laboratories	x	x
Healey	Adam	Broadcom Limited	x	x

Heck	Howard	Intel	x	x
Hegde	Raj	Broadcom	x	x
Ingham	Jonathan	Foxconn Interconnect Technology	x	
Isono	Hideki	Fujitsu Optical Components		x
Issenhuth	Tom	Huawei	x	x
Jackson	Ken	Sumitomo	x	
Kareti	Upen Reddy	Cisco	x	x
Kimber	Mark	Semtech	x	x
Kolesar	Paul	CommScope		x
Law	David	HPE	x	x
LeCheminant	Greg	Keysight Technologies	x	
Lewis	Dave	Lumentum	x	
Lewis	Jon	Dell		x
Li	Mike	Intel	x	x
Lim	Jane	Cisco	x	
Lingle, Jr.	Robert	OFS	x	
Lusted	Kent	Intel	x	x
Maki	Jeffery	Juniper Networks	x	x

Marris	Arthur	Cadence	x	x
McClellan	Brett	Marvell Semiconductor		x
McSorley	Greg	Amphenol	x	
Mellitz	Richard	Samtec	x	
Nakamoto	Edward	Spirent Communications	x	x
Nowell	Mark	Cisco	x	
Ofelt	David	Juniper Networks	x	x
Palkert	Tom	Molex - MACOM	x	x
Pepper	Gerald	Ixia	x	x
Philips	Jeff	Teledyne Lecroy	x	x
Ran	Adee	Intel	x	x
Sakai	Toshiaki	Socionext	x	x
Schube	Scott	Intel	x	
Shen	Zuowei	Google	x	
Sommers	Scott	Molex	x	
Sprague	Ted	Infinera	x	x
Sreekanth	PV	India Railways	x	x
Stassar	Peter	Huawei	x	x
Stone	Rob	Broadcom	x	x

Sun	Phil	Credo	x	x
Szczepanek	Andre	HSZ Consulting	x	x
Takahara	Tomoo	Fujitsu Laboratories	x	x
Tamura	Kohichi	Oclaro	x	x
Tracy	Nathan	TE Connectivity	x	x
Trowbridge	Steve	Nokia	x	x
Vitali	Marco	Sicoya	x	
Wang	Roy	HPE	x	x
Withey	James	Fluke	x	
Wu	Chengbin	ZTE		x
Xi	Huang	Huawei	x	x
Xu	Zidong	ZTE		x
Zhang	Yuanbin	ZTE	x	x
Zhiwei	Yangjing	ZTE		x
Zhuang	Yan	Huawei		x
Zimmerman	George	ADI, APL Group, BMW, Cisco, Commscope	x	x
Zivny	Pavel	Tektronix	x	x