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Motivation for new study item proposal on New LTE Frame Structure for TDD

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Background and Motivation

- TDD is a very promising duplex scheme in 4G evolution due to
  - The new available wideband spectrum assets are very likely from higher frequency band (e.g. above 3GHz) and they are unpaired
  - Channel reciprocity can be exploited to enable cost-effective Massive MIMO

- However, the TD-LTE frame structure (a.k.a FS 2) is not flexible enough to meet future requirements
  - Can NOT support faster Massive MIMO SRS/CQI feedback for better link adaptation, especially for medium-to-high speed
  - Can NOT effectively reduce latency to e.g. 1ms

- In addition, the TD-LTE frame structure (a.k.a FS 2) need to be improved in the following aspects
  - Control channel is not specifically protected when dynamic TDD feature is enabled
  - Complicated HARQ timing and a lot of HARQ processes, which result very high complexity especially for massive CA

Faster SRS/CSI for MIMO

- Motivations
  - Channel reciprocity based on SRS in TDD can efficiently improve the performance of MIMO, especially for Massive MIMO. **Fast SRS transmission and channel tracking can get more gain from better link adaptation for MIMO.**

Full Buffer, 1ms VS. 10ms SRS/CSI

	3km/h		30km/h	
	Aver.	Edge	Aver.	Edge
8H1V	19%	22%	83%	203%
16H2V	18%	30%	93%	299%

Burst traffic, 3km/h, 1ms VS. 10ms SRS/CSI

		RU:20%	RU:50%	RU:70%
8H1V	5% UPT	35%	38%	33%
	50% UPT	22%	36%	23%
16H2V	5% UPT	40%	70%	71%
	50% UPT	12%	29%	40%

  - In the existing TDD system, SRS can be transmitted only in UpPTS and uplink subframe, and channel state information can be reported only in uplink subframe**. For a TDD UL/DL configuration with large amount of downlink subframes, SRS transmission and channel state information feedback would be slow.**
  - In order to maximize the benefit from MIMO, enabling fast SRS transmission and channel tracking is promising. A proper new frame structure for TDD can achieve it.
- Benefits: Robustness against dynamic nature of interference and mobility
  - More link adaptation gains
  - More MU-MIMO gains
  - More gains for small packets and high speed users

Reduction of Latency

- Motivation
  - Latency is one of the important performance metrics and low-latency services would be more and more important for communication system. The latency is determined by several factors with two of them related to frame structure, frame alignment and HARQ RTT. The HARQ RTT is long in the existing TDD system. Frame alignment is also very long because PDSCH can be transmitted only in downlink subframe and DwPTS, and PUSCH can be transmitted only in uplink subframe.
  - A proper frame structure can lower the latency, and greatly reduce latency to e.g. similar as FDD

Short TTI		FDD	TDD-LTE (config1 DSUUD)	TDD-U (Example)
1ms (legacy)	UL	4.8ms	6.2ms	5.7ms
	DL	4.8ms	5.62ms	5.23ms
0.5ms TTI	UL	**2.4ms**	**3.49ms**	**2.92ms**
	DL	**2.4ms**	**2.93ms**	**2.8ms**
4/3 OS TTI	UL	**1.2ms**	**2.40ms**	**1.64ms**
	DL	**1.2ms**	**1.81ms**	**1.52ms**
2 OS TTI	UL	**0.6857ms**	**1.92ms**	**1.10ms**
	DL	**0.6857ms**	**1.43ms**	**1.00ms**
1 OS TTI	UL	**0.34ms**	**1.61ms**	**0.76ms**
	DL	**0.34ms**	**1.12ms**	**0.66ms**

Latency similar as FDD

Shorter HARQ RTT

- Motivation
  - The HARQ RTT is long in the existing TDD system with the long periodicity of UL/DL switch point, because downlink HARQ-ACK feedback can be performed only in uplink subframe and uplink HARQ-ACK feedback can be performed only in downlink subframe and DwPTS. Shorter HARQ RTT can improve the user perceive throughput, especially for small packets.

Burst Traffic

	Packet size	HARQ	5% UPT Gain	50% UPT Gain	Avg. UPT Gain	RU
8H1V	1M	n+2	11.6%	11.8%	10.5%	19.9%
	100K	n+2	**43.8%**	**25.0%**	**31.2%**	13.5%

* Baseline: HARQ n+4

Higher UPT gain

  - A proper frame structure can shorten the HARQ RTT.

- Benefits
  - Higher UPT gain especially for small packets
  - Significantly reduced complexity (buffer) for big packets (e.g. Massive CA)

Enhancement for dynamic TDD

- Motivation
  - **Control channel is not specifically protected when dynamic TDD feature is enabled.**
  - **UL/DL configurations that can dynamically be used are limited due to reference UL/DL configuration**. The HARQ timing varies with the TDD UL/DL configurations, which results in that the UL/DL configurations that can dynamically be used are limited and related to a reference UL/DL configuration.
  - **More HARQ-ACK bundling**. The available DL-reference UL/DL configurations are UL/DL configuration 2, 4 and 5, which obviously will result in more HARQ-ACK bundling according to the existing HARQ-ACK timing
  - A proper frame structure can enable better utilization of dynamic TDD.
- Better support of dynamic TDD
  - Control channel alignment across cells
  - Increase SRS transmission and uplink feedback opportunities
  - Improve UL/DL control channel reliability
  - Relax the restriction of reference UL/DL configuration in dynamic TDD

Proposed SI Objectives

- Study the possible new frame structure for TDD, take into account:
  - Fast SRS transmission and uplink control information feedback
  - Short HARQ RTT and Uniform HARQ timing
  - Better utilization of dynamic TDD
  - Lowering latency
  - Backward compatibility shall be preserved and forward compatibility could be considered as well
- Evaluate the benefits of the new frame structure
  - Identify possible deployment scenario
  - Identify the proper simulation assumptions, including traffic models
  - In particular evaluate the benefits of fast SRS transmission and fast uplink control information feedback, and the benefits for dynamic TDD
- Identify the related specification impacts on:
  - Physical layer signal and channel design
  - Physical layer procedures
  - Related work on RAN2, RAN3 and RAN4

Proposed SI Timeline

- Until the end of Rel-14
  - Study the possible new frame structure for TDD
  - Evaluate the benefits of the new frame structure
  - Identify the related specification impacts
  - Specify the identified new frame structure