FINANCIAL INCLUSION GLOBAL INITIATIVE (FIGI)

Security, Infrastructure and Trust Working Group

Test Campaign Report: Cross-border and inter-operator testing of Digital Financial Services, P2P money transfer

Report of the Quality of Service Workstream

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(3) The Security, Infrastructure and Trust Working Group (led by the ITU).

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About this document

This report was written by Wolfgang Balzer, Focus Infocom and was produced as part of the deliverable of the Quality of Service (QoS) Workstream of the FIGI Security Infrastructure and Trust Working Group.

The report describes the workflow and results of the testing campaign for (FI project code LID2661) in a testing campaign of digital financial services in Ghana, Rwanda and Uganda

The author would like to thank Kwame Baah-Acheamfuor for reviewing the report and facilitating the process for coordinating with the teams in Ghana, Rwanda and Uganda for the QoS field measurements. The author would also like to thank Vijay Mauree and Arnold Kibuuka for reviewing and editing the report and the Security, Infrastructure and Trust Working Group for their feedback.

If you would like to provide any additional information, please contact Vijay Mauree at tsbfigisit@itu.int.

This document is part of the deliverables of a project where creation of an underlying methodology was the other (main) deliverable. The present document is, in consistence with the original naming of deliverables, called *Report* while the term *Methodology* is used to refer to that deliverable.

For the convenience of reading as well as out of maintenance considerations, reference to standards documents and other materials in the present document are made in short form (example: P.1502 refers to ITU-T recommendation P.1502). The main reference is the References section of the Methodology document where also hyperlinks for access to original documents are provided.
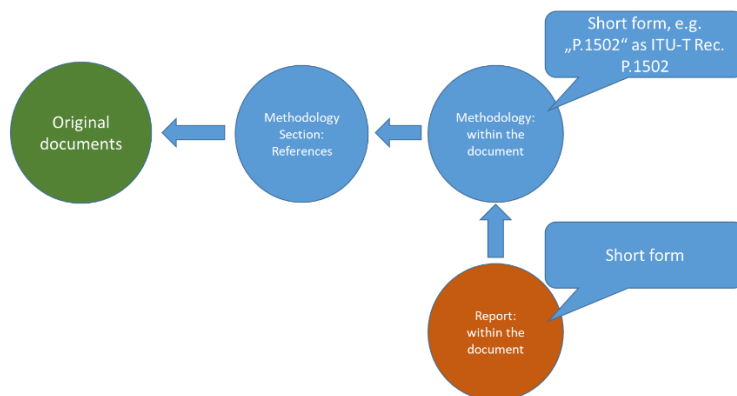
Figure 1 Mode of referencing used in the deliverables

Please note, however, that due to the project definition, the actual implementation of data processing is not included in the deliverables. Therefore, material such as SQL queries or data base related references are intended only as examples with no warranty of functionality.

1 Terms and abbreviations

Please note: The following is a copy of the T&A in the Methodology, providing for convenience of reading. Some terms listed may not be used in the present document.

Please refer to P.1502 for a full list of abbreviations. The following list contains only newly created abbreviations and, for convenience of reading, the most frequently used abbreviations in the context of Digital Financial Services.

API   Application Programming Interface

DAL   Device Assignment List (see Methodology for a full explanation)

DFS   Digital Financial Services

E2E   End-to-end

FTL   Field Test Lead (role name, the person responsible for directing field tests)

ITU-T   International Telecommunication Union, Telecom Standardization sector

KPI   Key Performance Indicator

MSW   Multi-stopwatch tool (see Methodology for a full description)

NSMS   Notification SMS

PIN   Personal Identification Number

P2P   Person-to-Person

QoE   Quality of Experience

QoS   Quality of Service

RAT   Radio Access Technology

TA   Transaction

TAL   Team Assignment List (see Methodology for a full explanation)

SMS   Short Message Service (also used for a single text message transmitted by SMS)

2 Campaign overview

The subject of this report is a 3-country testing campaign conducted between 11th May, 2020 and 6th June, 2020 (with campaign set-up, training and pre-testing from middle of April on)[1].
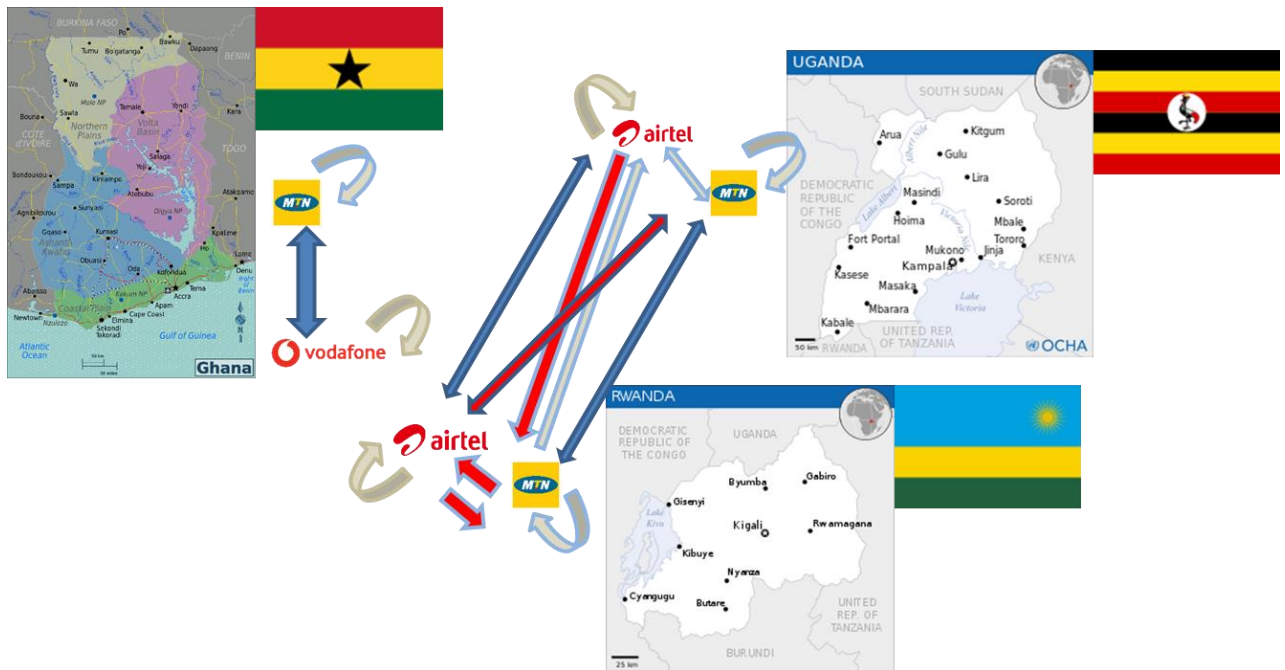
Figure 2 Symbolic campaign overview (image credits see footnote):

The campaign was done to test and validate extended methodologies on person-to-person money transfer in inter-operator, cross-country use cases. Also, the campaign aimed at getting an information base of DFS services in those countries.

Four categories of tests were performed:

- Same country (Intra-country), same operator/network
- Same country (Intra-country), different operators (inter-operator/network)
- Cross-border (Inter-country), same operator/network (i.e. same group)
- Cross-border (Inter-country), different operators/networks

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[1] Image credits:
Ghana map: By Burmesedays, minor amendments by Joelf - Own work based on Perry-Castañeda Library Map Collection Ghana Maps, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=22745324
Ghana flag: Public Domain, https://commons.wikimedia.org/w/index.php?curid=343073
Uganda map: By OCHA, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=34826076
Uganda flag: By tobias - From the Open ClipArt Library website., Public Domain, https://commons.wikimedia.org/w/index.php?curid=433085
Rwanda location map: By OCHA, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=34826078
Rwanda flag: By !Original:UnknownVector: Zscout370 -
http://www.primature.gov.rw/component/option,com_docman/task,doc_download/gid,859/Itemid,95/, Public Domain, https://commons.wikimedia.org/w/index.php?curid=327857
Logos:
MTN Group: Von MTN - mtn.co.za, Gemeinfrei, https://commons.wikimedia.org/w/index.php?curid=37719378
Vodafone Ghana: By Vodafone - Vodafone UK, Public Domain, https://en.wikipedia.org/w/index.php?curid=57428450
Airtel Africa: By airtel - www.airtel.in, Public Domain, https://en.wikipedia.org/w/index.php?curid=30177516

Remark: During the editing process of the report, some changes to wording with respect to use cases and team allocations were made. The tables and diagrams shown in the present documents use labels from original data (originating from the TAL and DAL) to enable referencing into that data. Some terms are used synonymously to each other, e.g. same country = intra-country or inter-country = cross-border. The above bullet point list also serves to show respective synonyms.

The following table shows the scenarios planned, and information on their status. Some tests could not be carried out due to either permanent restrictions, or due to unavailability at campaign time (i.e. NOT POSSIBLE means unavailable at the time of testing).

Table 1 Scenario overview, grouped by status and ordered alphabetically by owner team name. If limits for transfers are given, they are per day.

Scenario	Owner Team	Status	Characteristics
Cross-country Group network Airtel Rwanda to Airtel Uganda	Airtel Rwanda	Completed	Limited by 20 Transfers received by Airtel Uganda
Same Network Airtel Rwanda to Airtel Rwanda	Airtel Rwanda	Completed	Unlimited transfers
Same Network MTN Rwanda to MTN Rwanda	Airtel Rwanda	Completed	MTN SIMs used in the "Airtel" devices
Same Network Airtel Uganda to Airtel Uganda	Airtel Uganda	Completed	Limited to 20 Transfers out and 20 transfers in
Inter-network Airtel Uganda to MTN Uganda	Airtel Uganda	Completed	Limited by 20 Transfers out
Cross-country Group network Airtel Uganda to Airtel Rwanda	Airtel Uganda	Completed	Limited by 20 Transfers out
Inter-network MTN Ghana to Vodafone Ghana	MTN Ghana	Completed	Unlimited transfers
Same Network MTN Ghana to MTN Ghana	MTN Ghana	Completed	Unlimited transfers
Same Network MTN Rwanda to MTN Rwanda	MTN Rwanda	Completed	Limited to 10 Transfers out and 10 transfers in
Cross-country Group network MTN Rwanda to MTN Uganda	MTN Rwanda	Completed	Limited to 10 Transfers out and 10 transfers in
Cross-country Different network MTN Rwanda to Airtel Uganda	MTN Rwanda	Completed	Limited to 10 Transfers out
Cross-country Group network MTN Uganda to MTN Rwanda	MTN Uganda	Completed	Limited to 10 Transfers out received by MTN Rwanda
Inter-network MTN Uganda to Airtel Uganda	MTN Uganda	Completed	Limited by 20 Transfers received by Airtel Uganda
Same Network MTN Uganda to MTN Uganda	MTN Uganda	Completed	Unlimited transfers except to Ushs 7,000,000 (approx. 1900 USD)
Same Network Vodafone Ghana to Vodafone Ghana	Vodafone Ghana	Completed	Unlimited transfers
Inter-network Vodafone Ghana to MTN Ghana	Vodafone Ghana	Completed	Unlimited transfers
Inter-network Airtel Rwanda to MTN Rwanda	Airtel Rwanda	NOT POSSIBLE	No Inter-network interoperability

Scenario	Owner Team	Status	Characteristics
Cross-country Different network Airtel Rwanda to MTN Uganda	Airtel Rwanda	NOT POSSIBLE	No Cross-country interoperability
Cross-country Different network Airtel Uganda to MTN Rwanda	Airtel Uganda	NOT POSSIBLE (see Remark 1)	No Cross-country interoperability
Inter-network MTN Rwanda to Airtel Rwanda	MTN Rwanda	NOT POSSIBLE	No Inter-network interoperability
Cross-country Different network MTN Uganda to Airtel Rwanda	MTN Uganda	NOT POSSIBLE	No Cross-country interoperability

Remark 1: After closure of the campaign, further investigations were done with respect to feasibility of tests. It could be determined that transfers from Airtel Uganda to MTN Rwanda are, as of 14th July 2020 now possible.

3   Team structure and Data acquisition

In the originally planned structure (see Figure 3, the structure shown in the figure below would have been used, with a total of four teams (where a team may consist of one or more persons). Instead, due to travel/location restrictions due to the Covid19 pandemic, six teams were set up where each team was running tests in a separate location; see Figure 4. Team names were assigned due to the primary set-up of devices.

Remark: Please note that in a later phase of the project, one team was using a different set-up to increase the number of samples by parallel testing. The methodology was extended respectively to include the concept of "owner team" vs. configuration.
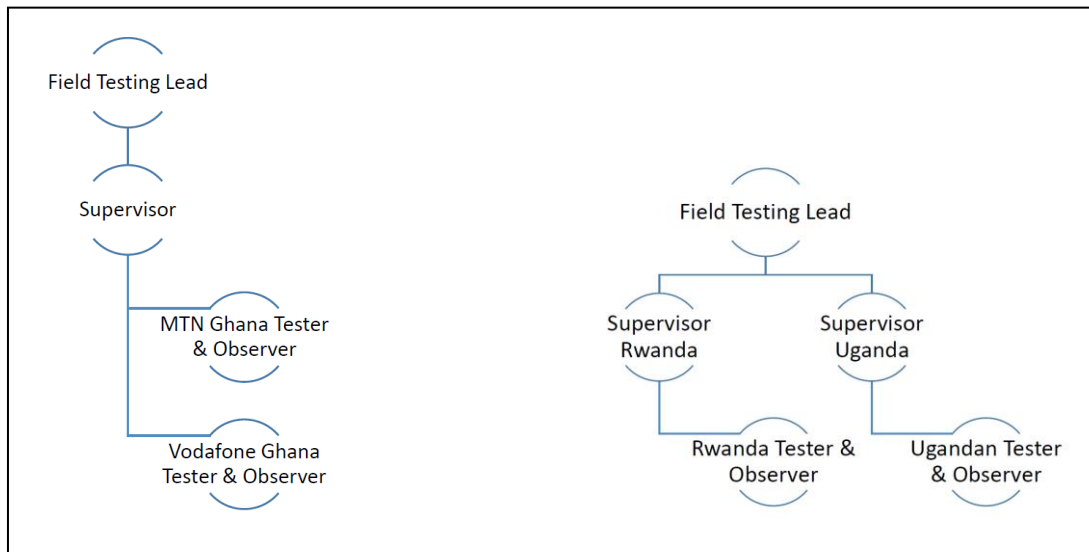
Figure 3 Originally planned structure of teams in Ghana, Rwanda and Uganda (w/o Corona)
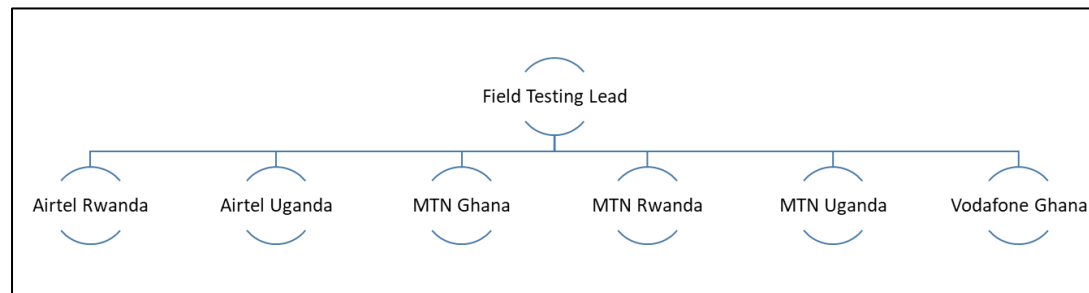
Figure 4 Actual project structure with team names equal to the primary set-up of respective devices. Each team was using a DFS testing toll, and an observation devices (see details in the text)

The set-up was following the Methodology. In order to reduce resource usage, the network background testing and the multi-stopwatch app were run on the same device. Also to save resources (e.g. transferred data volume), as the tests were done stationary, i.e. in the same location, mobile network background testing was not run over the whole DFS testing time, but only for a part of the time.

Devices were of type Samsung A10 (Android smartphone, "out of the box", i.e. unmodified). These devices were – also due to Covid19 restrictions - sourced by each team directly. Set-up was done locally with the MSW app and the DFS Observer app provided "over the air" by Focus Infocom and with support provided by Focus Infocom.

Remark: See Annex B for a copy of the set-up/training instructions to further describe the set-up process.

Before starting the actual measurements, several trial and validation runs were made, as well as a remotely conducted training of teams by support staff from Focus Infocom.

Originally, each team had their specific device set-up for one operator with respective naming, e.g. the team running the Vodafone Ghana set-up had also that name (logical team). In some cases, to mitigate transaction-count limits, device set-ups were changed to generate more samples for a specific scenario. Consequently, the logical structure of the data had to be

expanded to separate between the Owner team logical entity, and the Configuration logical entity.
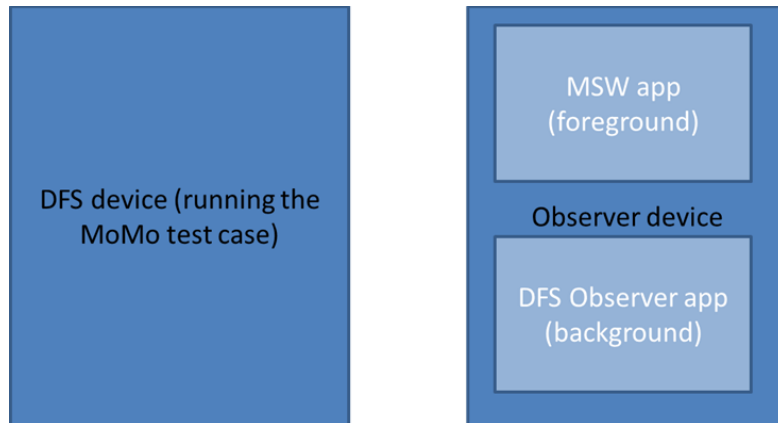
Figure 5 Set-up and role assignment for devices used in testing

Also for the same reason of mitigating transaction-count limits, the methodology was expanded to cover swapping of device roles, i.e. running devices part of the time in the DFS role and for the rest of the time running in the Observer role. This also led to a corresponding extension of the Methodology.
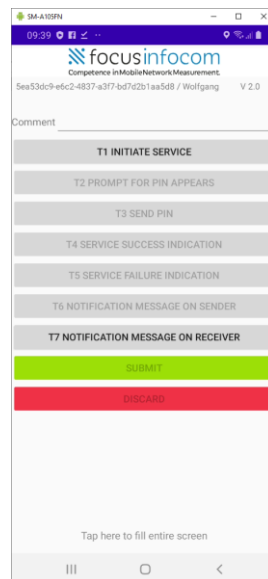
Figure 6 Sample screenshot of MSW. Buttons T1 to T7 are activated in a context-sensitive way following the event flow (see the Methodology document for details)

4 Data cleansing for final processing

4.1 Finalization of MSW data

Remark: A full description of the MSW tool can be found in the Methodology.

MSW uploads a data item every time the Submit or Discard button is tapped, i.e. when a transaction is either completed successfully, or a failure is recorded. The data structure of MSW data therefore consists of a group of files, each containing a single data item belonging to a single. Transaction.

MSW data processing was done in the following way:

1. Combine uploaded data by a Windows batch file concatenating all data into a single text file with a header line which is required for subsequent processing. In the current case, the header line also contained placeholder/instruction text to instruct users how to run subsequent steps of data handling.
2. Open the output file from step 1 in Excel®, inspect and finalize the data towards a file which can be imported into the processing database.

4.2 Inspection and finalization of the TAL

As planned, the final TAL structure defined in the Methodology was the result of an evolution which balanced requirements for simple and easy provision of data with the requirement of operational robustness and maximum safety against artefacts which could endanger data integrity and correctness of results.

In the "raw" TAL, team names and descriptions of activity flows were entered in free text. The formal TAL defines primary entry fields, and automatic generation of descriptors from these fields:

In the process of TAL finalization, primary input fields were added with content taken from the original input list. Then, generated descriptors were compared against original input, and differences were removed.

A typical situation is insertion of additional whitespace characters when inputting text directly. If the whitespace (e.g. a blank character) is at the end of a word or phrase, it is impossible to see directly; if whitespaces are between words or at the beginning of a line, it is at least hard to see, in particular, when one does not directly look for such artefacts. Therefore, when processing Excel® lists, formula-based text comparisons were used to identify such effects. This requires a certain effort; this pays off hugely later when data is processed in databases and where such "clean" data reduces the probability of undetected serious data-processing errors considerably.

Due to operational requirements, a re-assignment of devices and SIMs was done. Original text:

(E-mail as of 11.6.20)

MTN Rwanda

> *The labelled Team ID Airtel Rwanda in the MTN Rwanda log for 1st, 3rd to June was because Rwanda MTN SIM cards were used in the "Airtel Rwanda phones" to do tests to Airtel Uganda as MTN Rwanda is limited to 10 transactions a day. This was done to increase the transactions to 20 tests a day. The Team ID has been relabelled MTN Rwanda as the network was MTN.*

Consequentially, DAL and TAL have been expanded by respective OwnerTeam columns.

Data entities now are:

ConfigName (formerly "TeamName"). Default: Constructed from Operator and Country, = <Operator><blank space><Country>

OwnerTeam: The name of the team which holds/own a particular set of devices. By default, set to DeviceConfig.

If an assignment over time changes, this shall be expressed by multiple rows in the DAL, and respective entries in the TAL.

4.3 Inspection and finalization of the DAL

The finalization of the DAL was done following the same considerations and procedures as described in the previous subsection for the TAL. In essence, the free-text team names were replaced by constructed team names (from country and operator) as defined in the Methodology, and additional check code was added to make sure this was consistent with original input.

To check for the completeness and correctness of the DAL, an iterative process was then run (using the already imported MSW data) to check the MSW data against the DAL and see if all MSW ID's could be resolved to a valid team name. For input, the logs provide by the teams (or rather, the processed versions provided by the Field Test lead) were used.

5 Data Processing

5.1 Overview and Data object name reference

The following table shows the names assigned to the data objects. These names will be used to refer to respective data (meaning the respective cleansed version of that data) for the rest of this document.

Table 2 Data object and naming overview

Data object type	Short data object name	Name in database
MSW data combined from all uploaded data items, with column header added, into a single data file which is then imported into a table	MSW_Raw	Same as short name
MSW data with added reference information to configurations	MSW_Processed	
Device Assignment List data, cleansed and imported into a table	DAL	
Team Assignment List data, cleansed and imported into a table	TAL	
Imported TAL with additions for further processing	TAL_Processed	
MSW data combined with TAL information. This table contains the assignment to scenarios and is the input source for KPI computation.	MSW_TAL_Joined	
Data from background measurement, pre-processed into a single data file which is then imported into a table	AVDTA_Raw	
AVDTA data with relation to ConfigName/country and further information supporting data evaluation	AVDTA_Processed	
AVDTA data with assignment of test scenarios	AVDTA_TAL_Joined	

Figure 7 shows the data objects and the processing relations between them (please note that this figure is only a symbolic view; the textual description has preference).
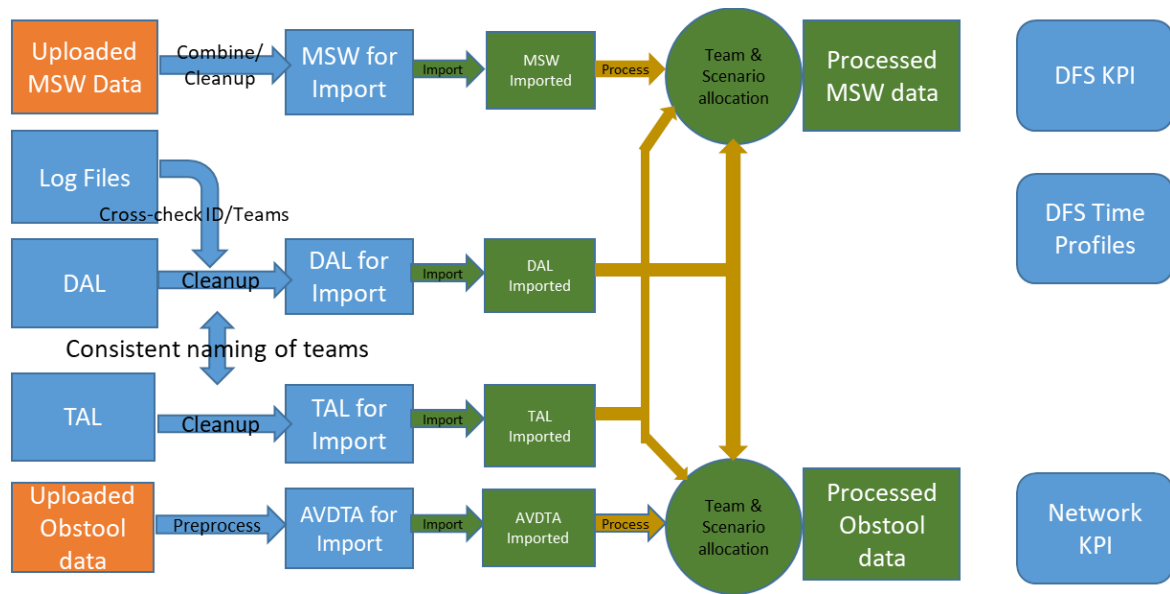
Figure 7 Symbolic overview of data objects and processing

5.2 Validation

5.2.1 Resolved: MSW items with contradicting content

- Anomalies A1: Nominal number of T exceeded but TA logged as successful
- Anomalies A2: T5 set but T4 and/or T6 also set

These issues have been resolved by consultation with the FTL (24.6.20). Decisions are:

1. For Anomalies A1: Ignore the limits for now and let us see what becomes of the events after the limits as success or failures. These limitations on Airtel Uganda and MTN Rwanda were learnt during the testing and we have to use the transactions done after the limits (i.e. 20 counts for Airtel Uganda and 10 counts for MTN Rwanda) to establish or otherwise any limits.
   Action: modify/extend mask-out logic such that in case of a successful TA, the TA is not masked out.
2. 2For Anomalies A2, I have consulted with the Teams and they have confirmed that T5 were hit-ons either by mistake or delayed success message. Please consider them as success and cross check.
   Action: Implemented by algorithm using presence of T6 in case of missing T4 as success.

5.2.2 Resolved: Transactions not covered by TAL

Upon joining MSW data with TAL information (to assign the testing scenario) it was detected that some TA were not covered by valid TAL entries. After investigating with the FTL, it was determined that the team did one extra day of measurements. The TAL was adjusted accordingly, and the data analysis was re-run to include the TA.

Actions:

- Modify the TAL (Team: Airtel Rwanda), change end date from 25.5.20 to 26.5.20

- Re-import the TAL
- Re-create tables/visualizations for TAL scenario time coverage
- Re-run the Join operation for MSW and ObsTool data
- Re-calculate aggregated KPI for DFS and network.

5.3 Process TAL

Create a TAL_Processed table containing the contents of the imported TAL plus

- Generated full scenario description.
- Generated unique index (ScenarioIX, short: SIX). This is – in connection with a look-up table also generated from TAL_Processed - used for labelling in cases where the full scenario name would be too long. Please note: If the TAL is created again, make sure the index is consistent.

5.4 Process MSW data

5.4.1 Inspect for remarks

The MSW tool had an entry field for remarks which allowed free-text entry. Due to the fact that this project was also a first-time application of this new tool, initially there was no "protocol" for usage of this field. This way, some first-hand insights could be gained on how testers would be using this field.

There were total of 467 otherwise valid MSW data items (i.e. assigned to a team and within the campaign time range) having non-empty remark fields.

Out of those, 382 items contained a "success" indication; all of those were however also technically classified as successful; also, all these entries had valid Submit timestamps and empty/NULL Discard timestamps. This means the remark was not a correction of a wrong entry (e.g. having hit the T5 button instead of the T4 button, but just a confirmation. It is assumed that the intention of the testers was to support the evaluation but training for future cases could include the instruction that this is not necessary as long as there are no button-entry errors to be corrected.

From the remaining 85 items, 27 contained wording referring to time-outs, and the vast majority of them were from Airtel Uganda with the specific text *'Timeout waiting for mule context to be completely started'* and technical classification as unsuccessful.

Also, in some other TA text pointed to problems related with the DFS service. From the remaining items, there was a cluster of "network down/network failure/connection problem" items, mostly from MTN Rwanda but also from other teams.

As part of the data cleansing procedure defined by the Methodology, clarification was sought about inclusion/exclusion of respective categories from the set of valid transactions. In this particular case, it was decided that two KPI for MTCD were computed to show a corridor of possible values; see subsequent sections for details.

Decisions about inclusion/exclusion of items based on content of remarks were implemented in the SQL statements which created the working set of data. This is encouraged as a general mode of operation as this provides a transparent, reproducible way of processing the data.

5.4.2 Create the MSW_Processed table

After import to the database, use the MSW_Raw table to create this table, to contain

- Columns ConfigName and Country. The content is either created directly via case statements using the MSW ID, or by joining respectively with the DAL.
- A column isSuccess which has the values 1 or 0 depending on the outcome of the transaction. This column will later be used for computation of KPI.
- Optional additional Day and Hour columns in case daily our hourly profiles shall be created.

Mask-out information derived from direct table content (e.g. via the Remark fields), or through mask-out or mask-in time ranges, can be added depending on actual data content.

5.4.3 Create the MSW_TAL_Joined table

This table uses the start and stop dates and the scenario names to identify, for each TA, the scenario it belongs to. In the database, this is done by joining the TAL on the ConfigName and the date range information.

Also, a per-day, per-ID **sequence number** is generated. Using this sequence number and the information on the maximum number of transactions per day given in the TAL, a mask-out indicator for further usage in KPI processing (`TAIsValidBySeqno`) is also generated.

The indicator is created in the query creating the table. Its value is 1 if the transaction shall be considered in KPI, and 0 otherwise. For instance, if the maximum number of transactions per day is 10, this indicator will be set to 1 for sequence numbers of 1-10 (including) and 0 for sequence numbers > 10.

Remark: The mask-out indicator will typically be extended to also cover individual cases based on time-range or information from the MSW Remark field.

5.4.4 Create MSW KPI

KPI generation is straightforward, following the usual methods for aggregation in data bases (grouping).

5.5 Process the background testing data (ObsTool/AVDTA)

5.5.1 Create the AVDTA_Processed table

After import to the database, use the AVDTA_Raw table to create this table, to contain

- Columns ConfigName and Country. The content is either created directly via case statements using the ObsTool ID (IMEI), or by joining respectively with the DAL.
- Additional Day, Hour and 10-minute slot columns to enable aggregation by time slot.

Depending on information from field logs, single transactions or time ranges may be masked out, e.g. in case unusual system or network behaviour was observed.

Please note that this table still contains data from the entire time the ObsTool was active. Masking out based on MSW information will be done in a subsequent step.

5.5.2 Create the AVDTA_TAL_Joined table

This table uses the start and stop dates and the scenario names to identify, for each TA, the scenario it belongs to. In the database, this is done by joining the TAL on the ConfigName and the date range information.

5.5.3 Calculate aggregated KPI per scenario

KPI generation is straightforward, following the usual methods for aggregation in data bases (grouping).

5.6 Joining MSW and AVDTA data

Due to the relatively small number of data items and given the fact that all tests were done in the same locations per team, the primary method was using per-scenario aggregation over all data, described in the following subsection.

5.6.1 Calculating MSW vs AVDTA KPI

This output is generated by joining the respective KPI tables by scenario such that a common output table is created. Each line shows a scenario, with columns for DFS and network KPI, respectively.

This operation does not create an output table; it is realized by a respective combined SQL statement which directly produces an Excel-ready output table.

6 Results

6.1 Scenario overview

The following graph shows the timing of scenarios during the campaign.

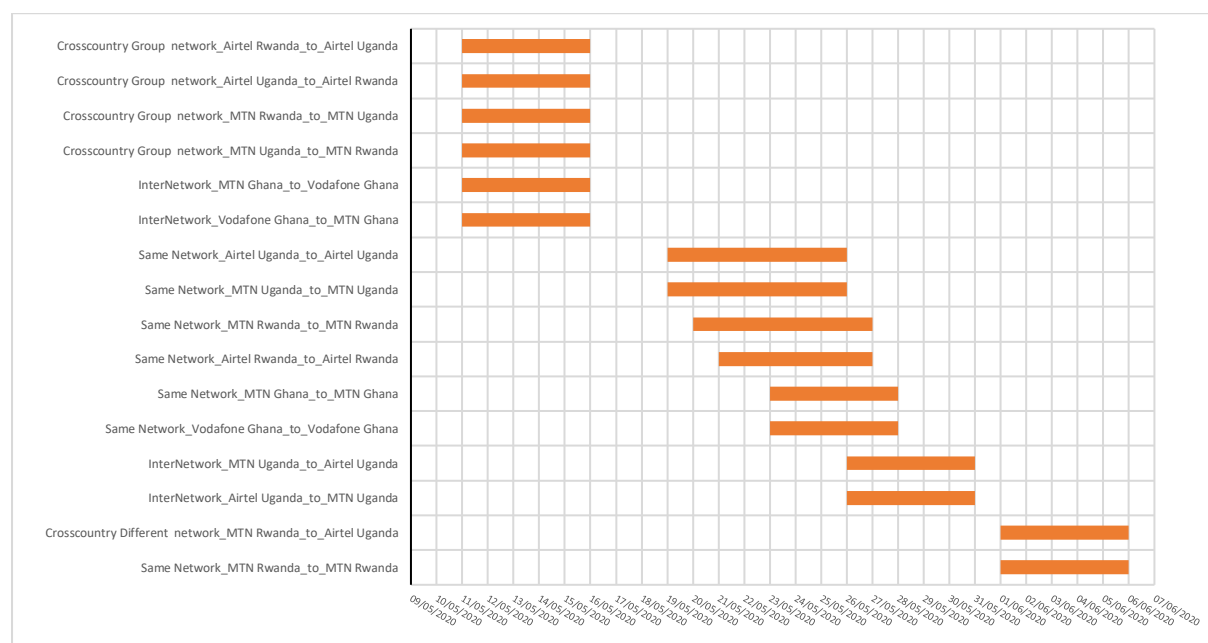Figure 8 Scenario overview by date. Please note that the scenario "Same network MTN Rwanda" appears twice as it was tested by the MTN Rwanda team between 20.5.20 and 26.5.20, and again by the Airtel Rwanda team between 1.6.20 and 5.6.20.

The table below shows details of scenario assignment to teams. Please note that the team and configuration names are typically identical (i.e. a team was using the same operator/country

set-up throughout the campaign) but in some cases differ where a team was using a different operator/country set-up.

Table 3 Overview of team assignments to scenarios. SIX is a logical scenario index for later use. Please note that the **To** date includes that day.

Team	A side config.	Scenario	From	Days	To	SIX	Remarks
Airtel Rwanda	Airtel Rwanda	Cross-country Group network Airtel Rwanda to Airtel Uganda	11.05.2020	5	15.05.2020	5	Limited by 20 Transfers received by Airtel Uganda
Airtel Uganda	Airtel Uganda	Cross-country Group network Airtel Uganda to Airtel Rwanda	11.05.2020	5	15.05.2020	6	Limited by 20 Transfers out
MTN Rwanda	MTN Rwanda	Cross-country Group network MTN Rwanda to MTN Uganda	11.05.2020	5	15.05.2020	7	Limited to 10 Transfers out and 10 transfers in
MTN Uganda	MTN Uganda	Cross-country Group network MTN Uganda to MTN Rwanda	11.05.2020	5	15.05.2020	8	Limited to 10 Transfers out received by MTN Rwanda
MTN Ghana	MTN Ghana	Inter-network MTN Ghana to Vodafone Ghana	11.05.2020	5	15.05.2020	11	Unlimited transfers
Vodafone Ghana	Vodafone Ghana	Inter-network Vodafone Ghana to MTN Ghana	11.05.2020	5	15.05.2020	15	Unlimited transfers
Airtel Uganda	Airtel Uganda	Same Network Airtel Uganda to Airtel Uganda	19.05.2020	7	25.05.2020	17	Limited to 20 Transfers out and 20 transfers in
MTN Uganda	MTN Uganda	Same Network MTN Uganda to MTN Uganda	19.05.2020	7	25.05.2020	20	Unlimited transfers except to Ushs 7,000,000
MTN Rwanda	MTN Rwanda	Same Network MTN Rwanda to MTN Rwanda	20.05.2020	7	26.05.2020	19	Limited to 10 Transfers out and 10 transfers in
Airtel Rwanda	Airtel Rwanda	Same Network Airtel Rwanda to Airtel Rwanda	21.05.2020	6	26.05.2020	16	Unlimited transfers
MTN Ghana	MTN Ghana	Same Network MTN Ghana to MTN Ghana	23.05.2020	5	27.05.2020	18	Unlimited transfers
Vodafone Ghana	Vodafone Ghana	Same Network Vodafone Ghana to Vodafone Ghana	23.05.2020	5	27.05.2020	21	Unlimited transfers
MTN Uganda	MTN Uganda	Inter-network MTN Uganda to Airtel Uganda	26.05.2020	5	30.05.2020	14	Limited by 20 Transfers received by Airtel Uganda
Airtel Uganda	Airtel Uganda	Inter-network Airtel Uganda to MTN Uganda	26.05.2020	5	30.05.2020	10	Limited by 20 Transfers out
MTN Rwanda	MTN Rwanda	Cross-country Different network MTN Rwanda to Airtel Uganda	01.06.2020	5	05.06.2020	3	Limited to 10 Transfers out
Airtel Rwanda	MTN Rwanda	Same network MTN Rwanda to MTN Rwanda	01.06.2020	5	05.06.2020	13	MTN SIMs used in the "Airtel" devices

6.2 Transaction model, MSW generic and standard KPI

As the implementation of DFS was not identical between countries/operators, the structure of measurement data was not entirely uniform. Specifically, there were cases where no "T4 events" were present. Figure 9 repeats an excerpt from the Methodology document to show the events and associated timerflags.
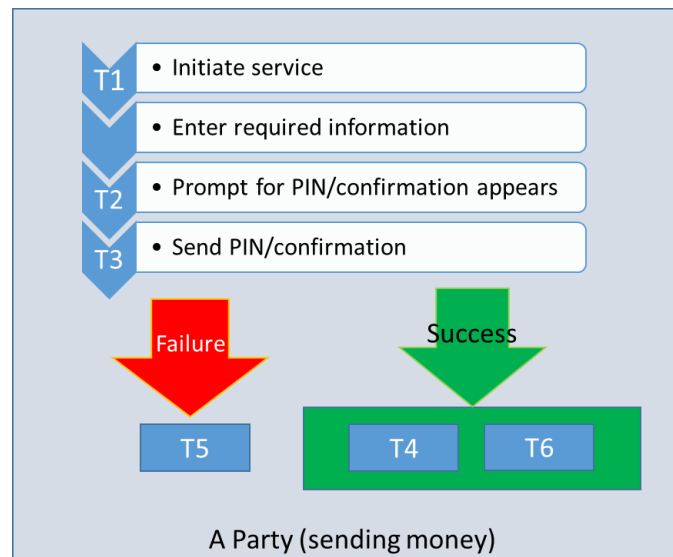
Figure 9 Principal events and associated timer flags

In some scenarios, the implementation produced no primary success indicators (or the notifications were so fast that they superseded these vents), so testers did not log T4. By formal definition of DFS KPI, this would mean that no MTCD could be computed. For pragmatic reasons, in such cases T6 was understood to be equivalent to T4. Nevertheless, to keep the formal structure, first a generic KPI termed "Execution time" (abbreviated ET) was defined. Respective results are shown in section MSW generic KPI per scenario. Then, in section MSW standardized KPI per scenario, the set applicable formal KPI is described and respective results are shown.

6.3   MSW transaction count by scenario

The following table shows the yield per scenario. Please note that for the "Same network MTN Rwanda" scenario, two teams were allocated to run tests due to the limitation of 10 transactions per day.

Table 4 MSW transaction count per scenario. Please note that for the MTN Rwanda intra-network scenario, two entries exist because two teams were tasked to test this scenario.

Scenario	A side team	Raw TA Count	Valid TA Count	Range from	Range to
Cross-country Different network MTN Rwanda to Airtel Uganda	MTN Rwanda	53	52	01.06.2020	05.06.2020
Cross-country Group network Airtel Rwanda to Airtel Uganda	Airtel Rwanda	107	107	11.05.2020	15.05.2020
Cross-country Group network Airtel Uganda to Airtel Rwanda	Airtel Uganda	129	114	11.05.2020	15.05.2020
Cross-country Group network MTN Rwanda to MTN Uganda	MTN Rwanda	87	62	11.05.2020	15.05.2020
Cross-country Group network MTN Uganda to MTN Rwanda	MTN Uganda	41	41	11.05.2020	15.05.2020
Inter-network Airtel Uganda to MTN Uganda	Airtel Uganda	211	211	26.05.2020	30.05.2020
Inter-network MTN Ghana to Vodafone Ghana	MTN Ghana	195	195	11.05.2020	15.05.2020
Inter-network MTN Uganda to Airtel Uganda	MTN Uganda	215	210	26.05.2020	30.05.2020
Inter-network Vodafone Ghana to MTN Ghana	Vodafone Ghana	156	156	11.05.2020	15.05.2020
Same Network Airtel Rwanda to Airtel Rwanda	Airtel Rwanda	330	330	21.05.2020	26.05.2020
Same Network Airtel Uganda to Airtel Uganda	Airtel Uganda	209	209	19.05.2020	25.05.2020
Same Network MTN Ghana to MTN Ghana	MTN Ghana	329	329	23.05.2020	27.05.2020
Same Network MTN Rwanda to MTN Rwanda	Airtel Rwanda	41	41	01.06.2020	05.06.2020

Same Network MTN Rwanda to MTN Rwanda	MTN Rwanda	88	87	20.05.2020	26.05.2020
Same Network MTN Uganda to MTN Uganda	MTN Uganda	328	328	19.05.2020	25.05.2020
Same Network Vodafone Ghana to Vodafone Ghana	Vodafone Ghana	270	270	23.05.2020	27.05.2020

	Total	**2789**	**2742**

As can be seen, some transactions had to be discarded as invalid. A transaction was valid if

- It could be assigned to a TAL-defined scenario, within the given date ranges
- The transaction was valid with respect to the DFS provider specific maximum-number limitations. As described in Validation, the validity rule was extended beyond the simple sequence-number based one by allowing also transactions beyond the limit if they had been marked as successful.
- The transaction was not 'blanked out' as indicated by comments. As a rule, all MSW data was uploaded and imported to the data base, including the ones which were marked as invalid through comments. Reasons were e.g. data entry (e.g. mistyping) errors. The number of such TA was, however, small. In most of the cases, the reason for discarding a TA was that the maximum-count limit was reached.

6.4   MSW generic KPI per scenario

In the graph below, the generic KPI "Execution time" (ET) is shown. ET is defined as the time between events T3 and T4. Basically, ET would be equal to the standard KPI MTCD.

However, as explained in the Methodology, ET is using a hybrid definition which surrogates T6 in case T4 is not present. Strictly speaking, cases where T4 is present would be reported as MTCD while cases where T4 is not present and T6 is not present would be reported as MTACT.
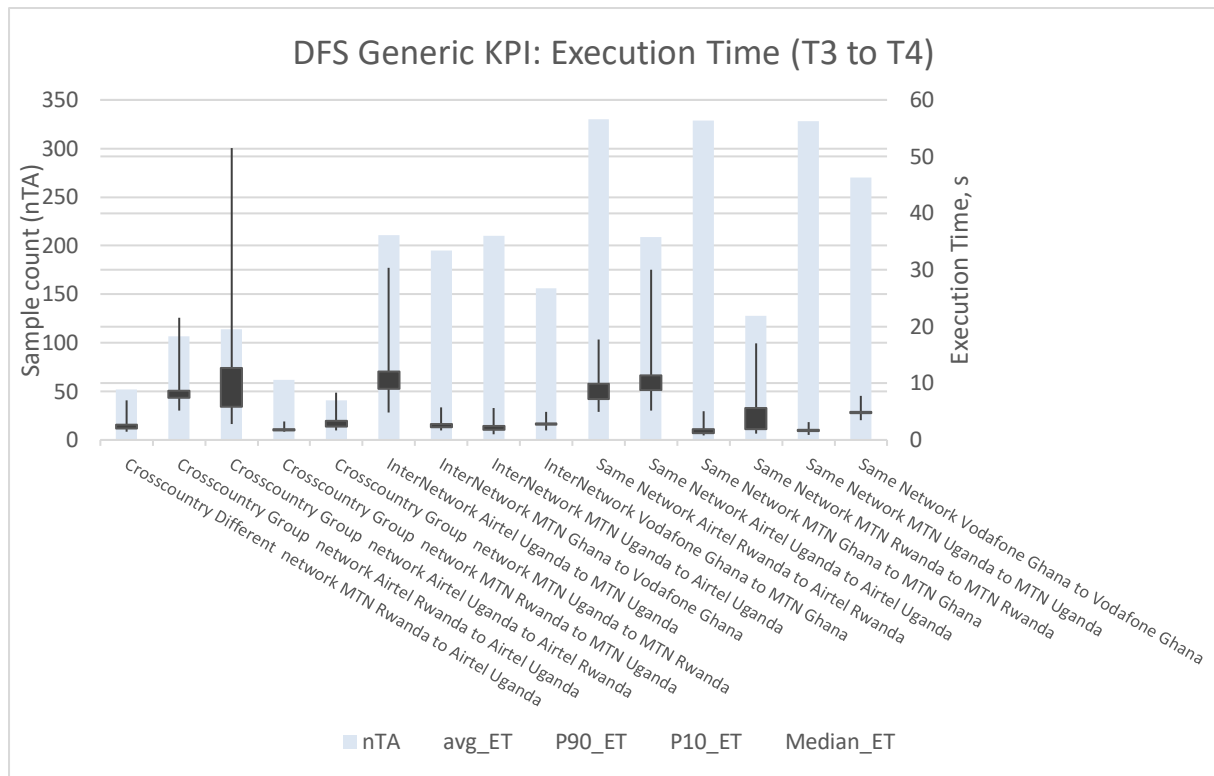
Figure 10 Generic DFS KPI "Execution time" (T3 to T4) per scenario. Horizontal markings/rectangles: Average and median values. Vertical lines indicate the 10% and 90% percentile (P10, P90), using the right-hand y axis. The colorized rectangles (left y-axis) show the number of valid samples.

Average as well as median values are shown here to give an indication about value spread of data. While the average (arithmetic mean) is commonly used in QoS, single extreme values in the data set can easily shift values. A median is, in this respect, more robust against single extreme values. In the figures, the width of the solid bar indicates the difference between average and median values.

The thin lines are used to show extremes. In the figures, the 10 and 90% percentile values (P10, P90) are used rather than the min and max values as inspection of data shows that there are, for many scenarios, single extremes which would degrade the graphical representation by compressing the scales for other data. The table at the end of the section shows P10 and P90 as well as min and max values.

Generally speaking, a lower sample count corresponds to a larger spread between median and average values; there are however exceptions.

Figure 11 shows the same data, but with a clipped y axis for ET to provide a better graphical resolution of ET values.

Figure 12 shows the same data but ordered by configuration (network/country)[2].

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[2] The tilt angle of text has been chosen deliberately different for more optical separation between the text ordering types.
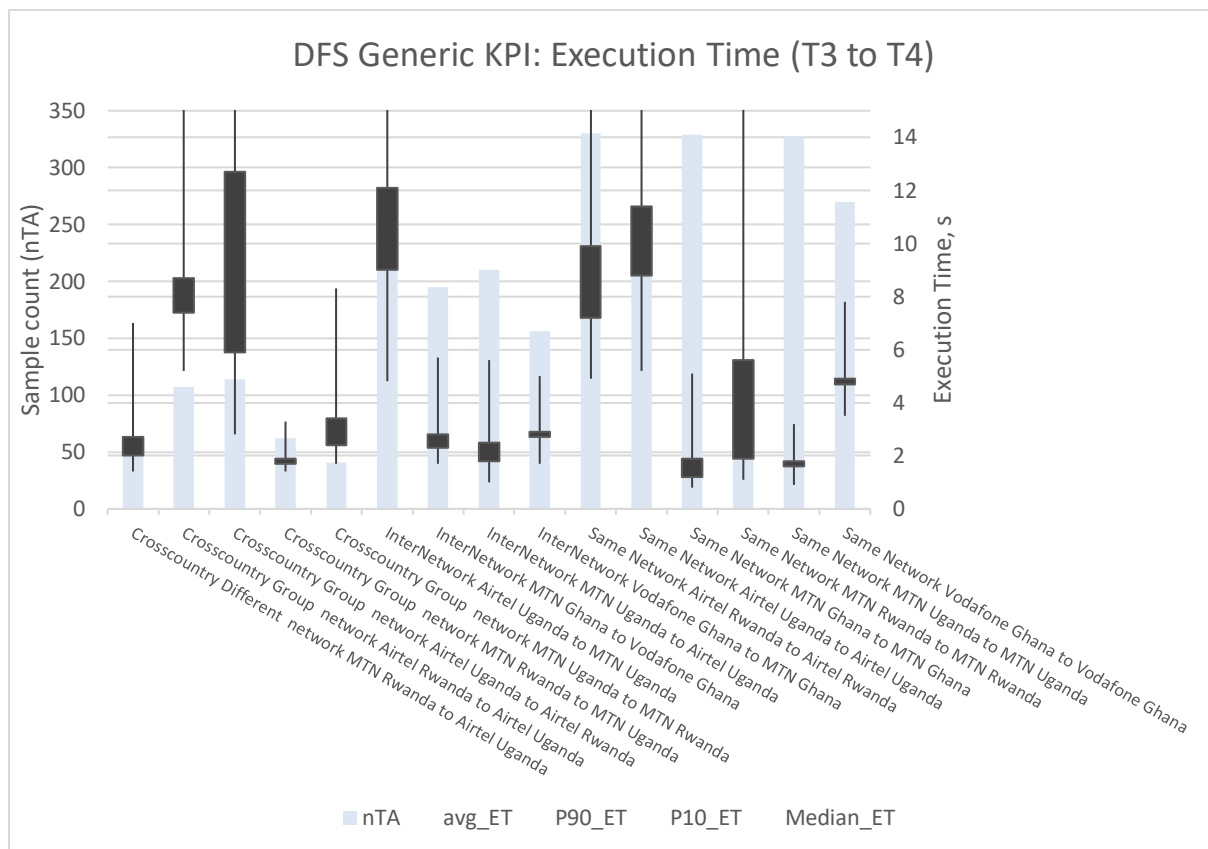
Figure 11 DFS Generic KPI "Execution Time", clipped y-axis (i.e. P90 not to scale)
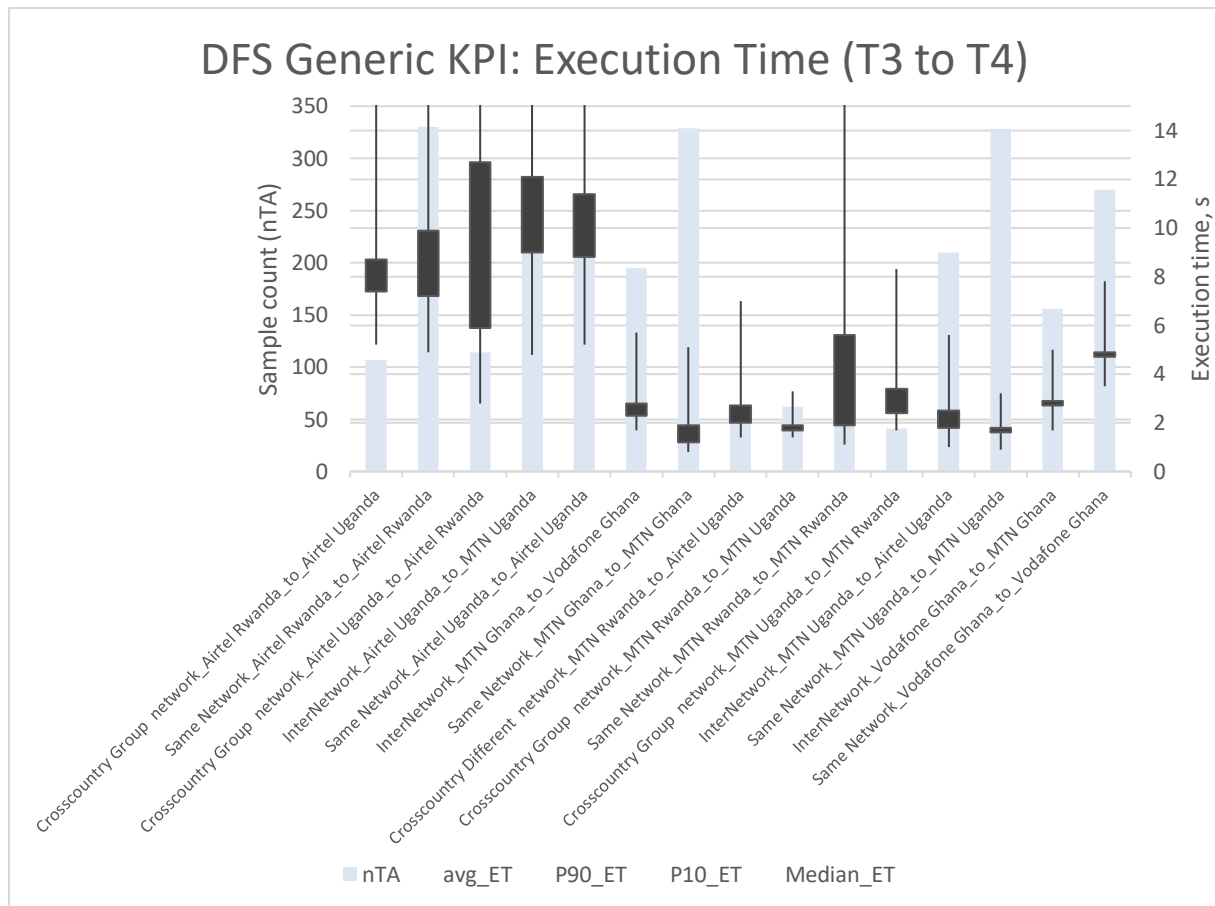
Figure 12 Generic KPI "Execution time" (ET) per scenario; sorted by configuration (network/country); clipped y axis for KPI value, i.e. some P90 values are not to scale

Table 5 shows the corresponding numerical data, in that case with the min and max values per scenario.

Table 5 Raw DFS KPI output. ST is the generic session time, see text for detail.

Scenario	nTA	nSuccess	avg_ET (s)	Median_ET (s)	min_ET (s)	max_ET (s)
Cross-country Different network MTN Rwanda to Airtel Uganda	52	37	2,7	2	0,7	10,4
Cross-country Group network Airtel Rwanda to Airtel Uganda	107	107	8,7	7,4	3,4	30,9
Cross-country Group network Airtel Uganda to Airtel Rwanda	114	74	12,7	5,9	1,7	105
Cross-country Group network MTN Rwanda to MTN Uganda	62	38	1,9	1,7	1,1	4
Cross-country Group network MTN Uganda to MTN Rwanda	41	39	3,4	2,4	0,7	13,6
Inter-network Airtel Uganda to MTN Uganda	211	208	12,1	9	1,3	85,5
Inter-network MTN Ghana to Vodafone Ghana	195	179	2,8	2,3	1	21,4
Inter-network MTN Uganda to Airtel Uganda	210	192	2,5	1,8	0,7	50,6
Inter-network Vodafone Ghana to MTN Ghana	156	153	2,9	2,7	0,8	5,9
Same Network Airtel Rwanda to Airtel Rwanda	330	329	9,9	7,2	2	203,1
Same Network Airtel Uganda to Airtel Uganda	209	206	11,4	8,8	0,8	81,3
Same Network MTN Ghana to MTN Ghana	329	305	1,9	1,2	0,5	15,2
Same Network MTN Rwanda to MTN Rwanda	128	122	5,6	1,9	0,6	20,2
Same Network MTN Uganda to MTN Uganda	328	302	1,8	1,6	0,5	10,3
Same Network Vodafone Ghana to Vodafone Ghana	270	262	4,9	4,7	0,6	17,3

6.5 MSW standardized KPI per scenario

6.5.1 KPI Selection

Definitions of simplified set (Table 5, ITU-T rec. P.1502), with current set of events. Figure 13 shows a symbolic representation of timerflag usage for the computation of these KPI.

Table 6 Used set of KPI and definition by timerflags. Note: MTCFT shown for formal reasons but not use due to asynchronous testing mode.

Indicator	Abbreviation	Computation with events used in this project
Money Transfer Core Duration [s]	MTCD	T4-T3
Money Transfer Raw Completion Time [s]	MTRCT	T4-T1
Money Transfer completion rate [%]	MTCR	T1 present, T4 present: success (see remark 1)
Money Transfer Full Completion Time [s]	MTFCT	T7-T1: Not reported due to testing mode (no B-side event tracking)
Money Transfer A-side Completion Time [s]	MTACT	T6-T1 (see remark 2)

Remark 1: As discussed previously, the numerical value depends on the definition of validity for TA. For pragmatic reasons, two values will subsequently be shown, establishing a value corridor.

Remark 2: With respect to the usage of T6 as surrogate for T4 in some cases (see section Transaction model, MSW generic and standard KPI), MTACT was computed formally but it should be noted that in such cases, MTACT will partially overlap with MTRCT.
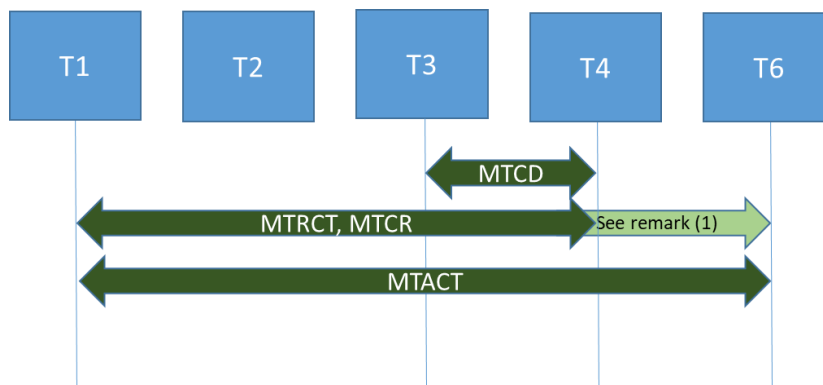

Figure 13 Usage of timerflags for DFS standard KPI. Remark 1: Cases where no T4 is present and T6 is used as a surrogate.

6.5.2 KPI Output, overview for all use cases

The following table shows the KPI per scenario. Please note that for the "Same Network MTN Rwanda to MTN Rwanda" scenario, there are two rows since this scenario has been carried out by two different teams.

Table 7 DFS standard KPI per scenario and Owner Team. See text for MTCR variants.

Owner Team	Scenario Name	MTCR_All (%)	MTCR _Restr (%)	MTCD (s)	MTRCT (s)	MTACT (s)
Airtel Rwanda	Cross-country Group network Airtel Rwanda to Airtel Uganda	100	100	8,7	(see remark 1)	67,6
Airtel Rwanda	Same Network Airtel Rwanda to Airtel Rwanda	99,7	99,7	9,9	(see remark 1)	54,9
Airtel Rwanda	Same Network MTN Rwanda to MTN Rwanda	90,2	90,2	14,4	(see remark 1)	102,4
Airtel Uganda	Cross-country Group network Airtel Uganda to Airtel Rwanda	64,9	77,9	12,7	48,8	53,1
Airtel Uganda	Inter-network Airtel Uganda to MTN Uganda	98,6	99	12,1	50,3	52,6
Airtel Uganda	Same Network Airtel Uganda to Airtel Uganda	98,6	98,6	11,4	40,6	46
MTN Ghana	Inter-network MTN Ghana to Vodafone Ghana	91,8	91,8	2,8	35,4	37,4
MTN Ghana	Same Network MTN Ghana to MTN Ghana	92,7	92,7	1,9	26,6	29
MTN Rwanda	Cross-country Different network MTN Rwanda to Airtel Uganda	71,2	75,5	2,7	58,8	67,8
MTN Rwanda	Cross-country Group network MTN Rwanda to MTN Uganda	61,3	69,1	1,9	61,2	79,8
MTN Rwanda	Same Network MTN Rwanda to MTN Rwanda	97,7	97,7	1,7	29,5	41,9
MTN Uganda	Cross-country Group network MTN Uganda to MTN Rwanda	95,1	95,1	3,4	68,3	74,9
MTN Uganda	Inter-network MTN Uganda to Airtel Uganda	91,4	91,9	2,5	35,4	50
MTN Uganda	Same Network MTN Uganda to MTN Uganda	92,1	92,1	1,8	26,7	35
Vodafone Ghana	Inter-network Vodafone Ghana to MTN Ghana	98,1	99,4	2,9	46,8	57,8
Vodafone Ghana	Same Network Vodafone Ghana to Vodafone Ghana	97	98,5	4,9	34	41,1

Remark 1: In some cases MTRCT is not provided. These were the cases where no T4 exists, i.e. where formally no computation of MTRCT is possible. Due to the use of T6 as surrogate for T4, MTACT values have to be used instead.

According to the consideration given in the previous subsection, there are two MTCR values.

MTCR_All is computed using all transactions with valid sequence number and not excluded by other basic mechanisms.

MTCR_Restr is computed from a restricted set. Transactions having remarks indicating either mobile network or DFS subsystem problems are excluded.

These two values can be understood as giving a corridor for the MTCR value. The higher the degree of exclusion of network or DFS service related transactions is, the higher the MTCR value will be. For instance, if network related failures are left in the set, but DFS subsystem related ones are excluded, the MTCR value will be between MTCR_All and MTCR_Restr.

When interpreting the data, MTCD and MTCR has to be looked at as a closely related couple[3]. A short MTCD (equivalent to a session time) alone does not indicate a well-working service, as success rates still could be low, even more so if time-outs are involved as they will effectively remove transactions with poor session time from the averaged set. An example would be the scenarios "Cross-country Different network MTN Rwanda to Airtel Uganda" or, even more pronounced, "Cross-country Group network MTN Rwanda to MTN Uganda" where the MTCD shows rather small (good) values but the success rates are also low, in contrast to other cases where MTCD and MTCR are both in a "fair to good" range.

As for MTRCD and MTCACT, these indicators can be expected to have more fluctuation as they contain manual operation times. On the other hand, these indicators include multiple interactions with the service, so they are considered as providing valuable information nevertheless. As for the component of manual interaction, it is assumed that there are also mitigating effects: When testers are getting more experienced, their transaction-to-transaction operating performance will become more uniform, which should also be comparable with not-too-infrequent users who also will gain experience and dexterity.

When looking at MTRCD and MTACT, some extremes come to attention, most prominently the "Same Network MTN Rwanda to MTN Rwanda" scenario carried out by the Airtel Rwanda team. As will be shown in subsequent sections, this team had a rather poor mobile network coverage for MTN Rwanda. This confirms the value of MTRCD and MTCACT as indicative of mobile network coverage effects as well of providing a full view of DFS performance.

6.5.3 KPI output per use case category

In the following subsections, results are shown by category.

Please note: In some cases MTRCT is not provided. These were the cases where no T4 exists, i.e. where formally no computation of MTRCT is possible. Due to the use of T6 as surrogate for T4, MTACT values have to be used instead.

6.5.3.1.1 Intra-country (same country)
6.5.3.1.2 Same operator

Owner Team	Scenario Name	MTCR_All (%)	MTCR_Restr (%)	MTCD (s)	MTRCT (s)	MTACT (s)
Airtel Rwanda	Same Network Airtel Rwanda to Airtel Rwanda	99,7	99,7	9,9		54,9
Airtel Rwanda	Same Network MTN Rwanda to MTN Rwanda	90,2	90,2	14,4		102,4
Airtel Uganda	Same Network Airtel Uganda to Airtel Uganda	98,6	98,6	11,4	40,6	46
MTN Ghana	Same Network MTN Ghana to MTN Ghana	92,7	92,7	1,9	26,6	29
MTN Rwanda	Same Network MTN Rwanda to MTN Rwanda	97,7	97,7	1,7	29,5	41,9
MTN Uganda	Same Network MTN Uganda to MTN Uganda	92,1	92,1	1,8	26,7	35
Vodafone Ghana	Same Network Vodafone Ghana to Vodafone Ghana	97	98,5	4,9	34	41,1

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[3] This is similar to mobile network QoS KPI types Session Time and Success Rate, in particular when time-outs are involved.

Owner Team	Scenario Name	MTCR_All (%)	MTCR_Restr (%)	MTCD (s)	MTRCT (s)	MTACT (s)
Airtel Uganda	InterNetwork Airtel Uganda to MTN Uganda	98,6	99	12,1	50,3	52,6
MTN Ghana	InterNetwork MTN Ghana to Vodafone Ghana	91,8	91,8	2,8	35,4	37,4
MTN Uganda	InterNetwork MTN Uganda to Airtel Uganda	91,4	91,9	2,5	35,4	50
Vodafone Ghana	InterNetwork Vodafone Ghana to MTN Ghana	98,1	99,4	2,9	46,8	57,8

6.5.3.1.4   Inter-country (cross-border)

6.5.3.1.5   Same operator (group)

Owner Team	Scenario Name	MTCR_All (%)	MTCR_Restr (%)	MTCD(s)	MTRCT (s)	MTACT (s)
Airtel Rwanda	Crosscountry Group network Airtel Rwanda to Airtel Uganda	100	100	8,7		67,6
Airtel Uganda	Crosscountry Group network Airtel Uganda to Airtel Rwanda	64,9	77,9	12,7	48,8	53,1
MTN Rwanda	Crosscountry Group network MTN Rwanda to MTN Uganda	61,3	69,1	1,9	61,2	79,8
MTN Uganda	Crosscountry Group network MTN Uganda to MTN Rwanda	95,1	95,1	3,4	68,3	74,9

Owner Team	Scenario Name	MTCR_All (%)	MTCR_Restr (%)	MTCD (s)	MTRCT (s)	MTACT (s)
MTN Rwanda	Crosscountry Different network MTN Rwanda to Airtel Uganda	71,2	75,5	2,7	58,8	67,8

6.5.4   Details

The table below shows more details for DFS KPI. For description of percentile values, refer to MSW generic KPI per scenario. nTA is the number of all valid transactions in the set. nValidMinSet is the number of transactions with TA excluded where testers indicated mobile-network or DFS service unavailability.

Table 8 Standard DFS KPI with min/max and selected percentile values for MTCD. See text for further details.

Owner Team	Scenario Name	nSuccess	nValidMinSet	nTA	MTCD (s)	P90_MTCD (s)	P10_MTCD (s)	Median_MTCD (s)	MTRCT (s)	MTACT (s)	max_MTCD (s)	min_MTCD (s)
Airtel Rwanda	Cross-country Group network Airtel Rwanda to Airtel Uganda	107	107	107	8,7	21,6	5,2	7,4		67,6	30,9	3,4
Airtel Rwanda	Same Network Airtel Rwanda to Airtel Rwanda	329	330	330	9,9	17,7	4,9	7,2		54,9	203,1	2
Airtel Rwanda	Same Network MTN Rwanda to MTN Rwanda	37	41	41	14,4	17	1,1	1,9		102,4	20,2	2,5
Airtel Uganda	Cross-country Group network Airtel Uganda to Airtel Rwanda	74	95	114	12,7	51,5	2,8	5,9	48,8	53,1	105	1,7
Airtel Uganda	Inter-network Airtel Uganda to MTN Uganda	208	210	211	12,1	30,4	4,8	9	50,3	52,6	85,5	1,3
Airtel Uganda	Same Network Airtel Uganda to Airtel Uganda	206	209	209	11,4	30	5,2	8,8	40,6	46	81,3	0,8
MTN Ghana	Inter-network MTN Ghana to Vodafone Ghana	179	195	195	2,8	5,7	1,7	2,3	35,4	37,4	21,4	1
MTN Ghana	Same Network MTN Ghana to MTN Ghana	305	329	329	1,9	5,1	0,8	1,2	26,6	29	15,2	0,5
MTN Rwanda	Cross-country Different network MTN Rwanda to Airtel Uganda	37	49	52	2,7	7	1,4	2	58,8	67,8	10,4	0,7
MTN Rwanda	Cross-country Group network MTN Rwanda to MTN Uganda	38	55	62	1,9	3,3	1,4	1,7	61,2	79,8	4	1,1
MTN Rwanda	Same Network MTN Rwanda to MTN Rwanda	85	87	87	1,7	17	1,1	1,9	29,5	41,9	4,6	0,6
MTN Uganda	Cross-country Group network MTN Uganda to MTN Rwanda	39	41	41	3,4	8,3	1,7	2,4	68,3	74,9	13,6	0,7
MTN Uganda	Inter-network MTN Uganda to Airtel Uganda	192	209	210	2,5	5,6	1	1,8	35,4	50	50,6	0,7
MTN Uganda	Same Network MTN Uganda to MTN Uganda	302	328	328	1,8	3,2	0,9	1,6	26,7	35	10,3	0,5
Vodafone Ghana	Inter-network Vodafone Ghana to MTN Ghana	153	154	156	2,9	5	1,7	2,7	46,8	57,8	5,9	0,8
Vodafone Ghana	Same Network Vodafone Ghana to Vodafone Ghana	262	266	270	4,9	7,8	3,5	4,7	34	41,1	17,3	0,6

6.6 Mobile-network measurement TA count per scenario

As data in a DFS transaction is transferred over mobile network, the overall DFS performance also depends on network performance. If this dependence transforms into a perceivable correlation between respective KPI, will depend in the relative contributions of each element, as outlined in P.1502. In short, the effect of network performance will only be visible in DFS KPI if that performance is less than perfect, and if the performance of the DFS infrastructure is not the dominating factor[4].

Using background measurements to determine transport network performance is therefore a means to get information about these relations and to gain respective insights.

As in the case of DFS tests, the statistical error in network KPI depends on the number of samples, in this case the number of transactions done in the network-testing scenario. The following table provides an overview of item count per use case scenario. In total, there was a total of 15936 data items collected, with 15093 items being valid with respect to date ranges.

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[4] Please also refer to section 15 of the Methodology for more considerations on this topic.

Table 9 Number of network background testing transactions per scenario.

Scenario	Item Count
Cross-country Different network MTN Rwanda to Airtel Uganda	177
Cross-country Group network Airtel Rwanda to Airtel Uganda	158
Cross-country Group network Airtel Uganda to Airtel Rwanda	270
Cross-country Group network MTN Rwanda to MTN Uganda	425
Cross-country Group network MTN Uganda to MTN Rwanda	160
Inter-network Airtel Uganda to MTN Uganda	9759
Inter-network MTN Ghana to Vodafone Ghana	362
Inter-network MTN Uganda to Airtel Uganda	138
Inter-network Vodafone Ghana to MTN Ghana	195
Same Network Airtel Rwanda to Airtel Rwanda	450
Same Network Airtel Uganda to Airtel Uganda	1569
Same Network MTN Ghana to MTN Ghana	281
Same Network MTN Rwanda to MTN Rwanda	418
Same Network MTN Uganda to MTN Uganda	142
Same Network Vodafone Ghana to Vodafone Ghana	589

In some cases, the ObsTool app was not running over the whole measurement time. Part of this be to the fact that an app running in the background can be stopped after some time by the operating system[5]. As, in this particular case, it was decided that background network testing was not high priority. On the other hand, tests were done stationary, i.e. all tests were done in the same place. It is however assumed that the smaller time coverage is still giving sufficient information about local network coverage.

6.7   Mobile-network KPI per scenario

6.7.1   KPI and validity rules used

The scenario was designed to give a coarse impression of local packet-data performance, i.e. to run rather light on network usage (no data-heavy test cases). However, due to the specifics of the test, reference material was hosted on Focus Infocom's servers. This means that overall testing conditions[6] also included the data route between respective national networks and Focus Infocom's infrastructure.

The following test cases and KPI were used:

Test case	KPI
Web Browsing (ETSI Kepler SP reference web site)	**End to end session time (E2E ST)** in case of successful transactions. In contrast to the TS 102 250/E.804 Session Time, the time window begins with the start of web site download (not with reception of the first package) **End to End Success Rate** (percentage of transactions successfully completed, from all valid TA. A valid TA is a

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[5] In the original set-up, it was planned to run the ObsTool on a separate device (a total of 3 devices per team: DFS, MSW and ObsTool). As the scope was expanded, and due to the fact that, due to Corona restrictions, the devices could not be handed over between the teams, this would have led to a significantly higher demand for resources. Therefore, it had been decided to run the ObsTool on the same device as the MSW.

[6] Mainly the multi-country nature of testing, the limited scope of the campaign (not meant to be representative or benchmark testing) along with the expressed secondary role of network KPI.

Test case	KPI
	TA run via mobile network (not via WiFi), and not blanked out by e.g. a User Break indication.
HTTP DL with 3 Mbyte file; time-out 30 sec	**End to end session time (ST_E2E)** in case of successful transactions. Analogously to Web browsing, this ST includes the initial start time. **End to End Success Rate** (percentage of transactions successfully completed, from all valid TA. Evaluation is done in fixed-size mode, i.e. a TA which ran into a time-out is not counted as successful. **Mean Data Rate End To End: (MDR_E2E):** Effective data rate. This value is also output if the result if the TA is unsuccessful (e.-g. dropped or ran into time-out); in that case the transferred data up to the stopping point, and the time expired, is used to compute the MDR.
HTTP UL with 1 Mbyte file in fixed-time mode; time window 30 sec (hybrid mode)	In hybrid mode, the TA ends either when the intended data volume is transferred, or the time window is expired. In this mode, reaching the end of the time-window does not result in the result "unsuccessful". If desired, a computational "unsuccessful" state can be created by evaluating the TA duration. **End to end session time (ST_E2E).** By computation, this value is created only when the end of the time window is not reached (to stay consistent with standardized KPI computation. Analogously to Web browsing, this ST includes the initial start time. **End to End Success Rate** (percentage of transactions successfully completed, from all valid TA. Evaluation is done in "computational fixed-size mode", i.e. a TA which ran into a time-out is not counted as successful. **Mean Data Rate End To End: (MDR_E2E):** Effective data rate. This value is also output if the result if the TA is unsuccessful (e.-g. dropped or ran into time-out); in that case the transferred data up to the stopping point, and the time expired, is used to compute the MDR.

The definition of valid TA excludes transactions which are taken via WiFi, were interrupted by the user ("user break") or are masked-out otherwise. Also, through joining with the TAL, there is an effective time-windowing to exclude TA taken outside the date range of respective scenario. Due to the fact that measurements were taken stationary (in the same location), there is, however, no time windowing with respect to MSW time ranges.

MDR values are, different from standard MDR averaging, taken over all TA including unsuccessful ones. This avoids biasing towards higher expected values which occurs when timed-out transactions are excluded from averaging.

ST values are calculated over values from successful TA only to avoid inconsistencies by clipping. When interpreting data, success rates need to be considered along with ST values.

6.7.2 Network KPI Overview

This section provides an overview of network KPI from background testing. A detailed table can be found in Annex C: Network KPI overview from background testing.

For selection of KPI and details of computation, see section KPI and validity rules used.

The following table shows data aggregated per network, i.e. combining data from different scenarios having the same A side configuration.

Table 10 Network KPI per network. Abbreviations: SR=Success Rate; DL=HTTP DL; UL: HTTP_UL

	Airtel Rwanda	Airtel Uganda	MTN Ghana	MTN Rwanda	MTN Uganda	Vodafone Ghana
Web_SR (%)	39,3	92,4	46,6	37,8	55	64,2
Web_ST_E2E (s)	5,2	1,8	5,1	4,4	3	6,2
DL_SR (%)	86,7	82,6	68,2	82,9	95,6	63,2
DL_ST_E2E (s)	15,3	7,5	14,3	8,1	8,7	16,4
DL_MDR_E2E (Mbit/s)	1,7	4,3	1,8	3,7	3,4	1,4
UL_SR (%)	99	97,4	100	91,7	100	100
UL_ST_E2E (s)	9	6,5	10,7	12,1	9,1	7,7
UL_MDR_E2E (Mbit/s)	1,2	1,7	1,2	1,2	1,1	1,3

The figures below show visualizations of KPI per scenario and per network.
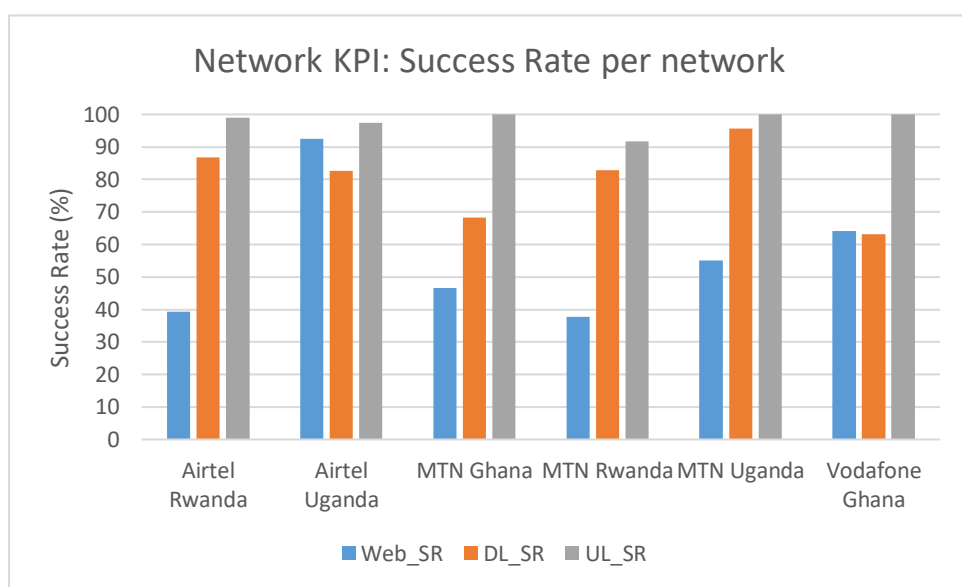
Figure 14 Network KPI: Success Rate per network
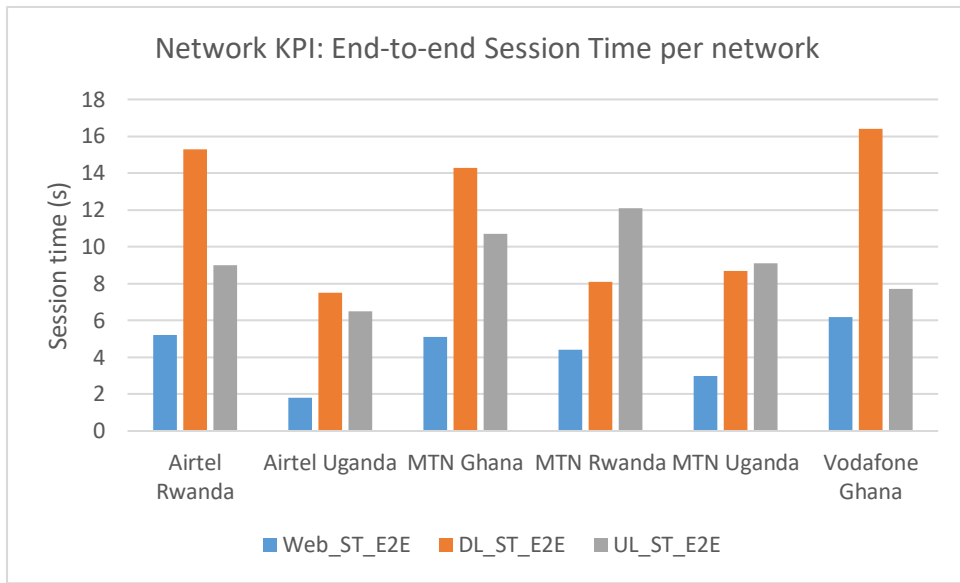
Figure 15 Network KPI: E2E Session Time per network
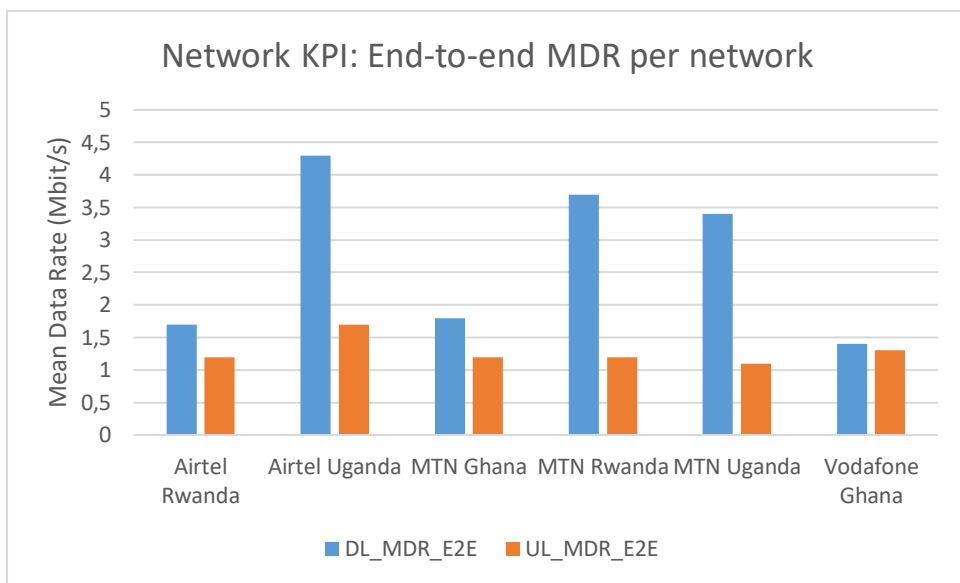
Figure 16 Network KPI: E2E Mean Data Rate per network
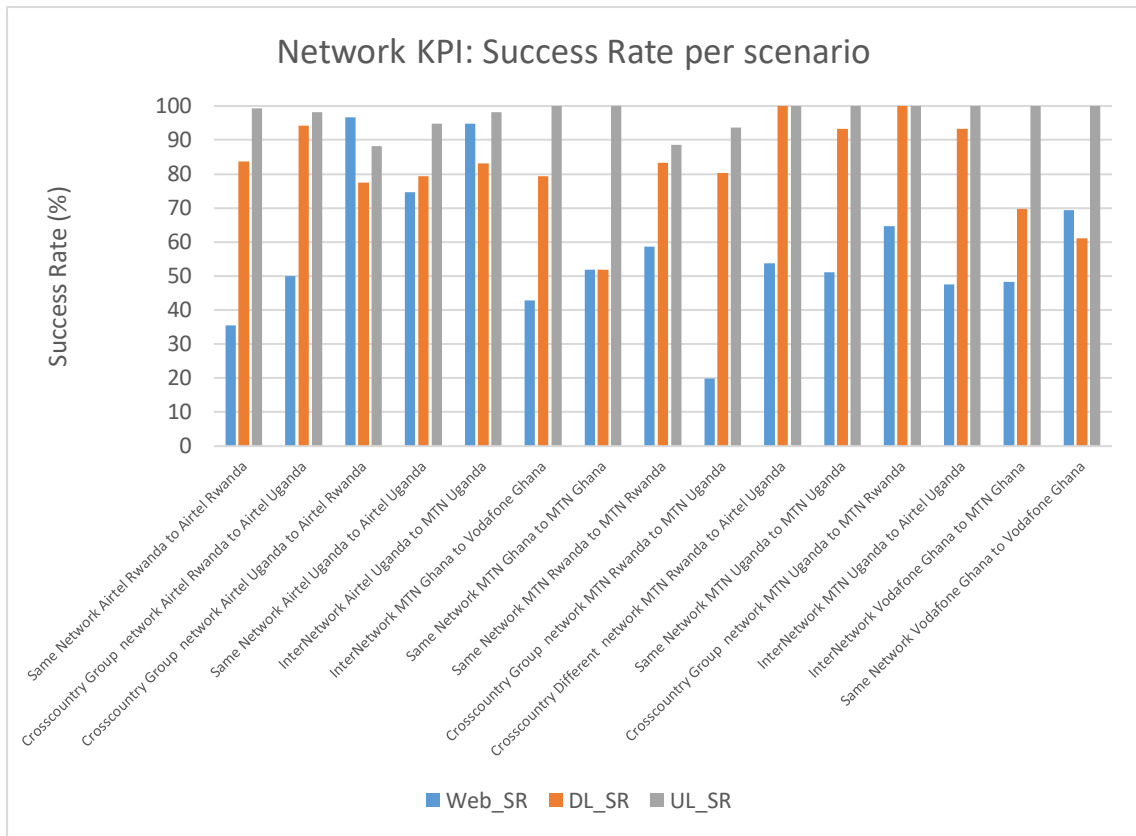
Figure 17 Network KPI: Success Rate per scenario

Table 11 Network KPI end-to-end Session Time per scenario
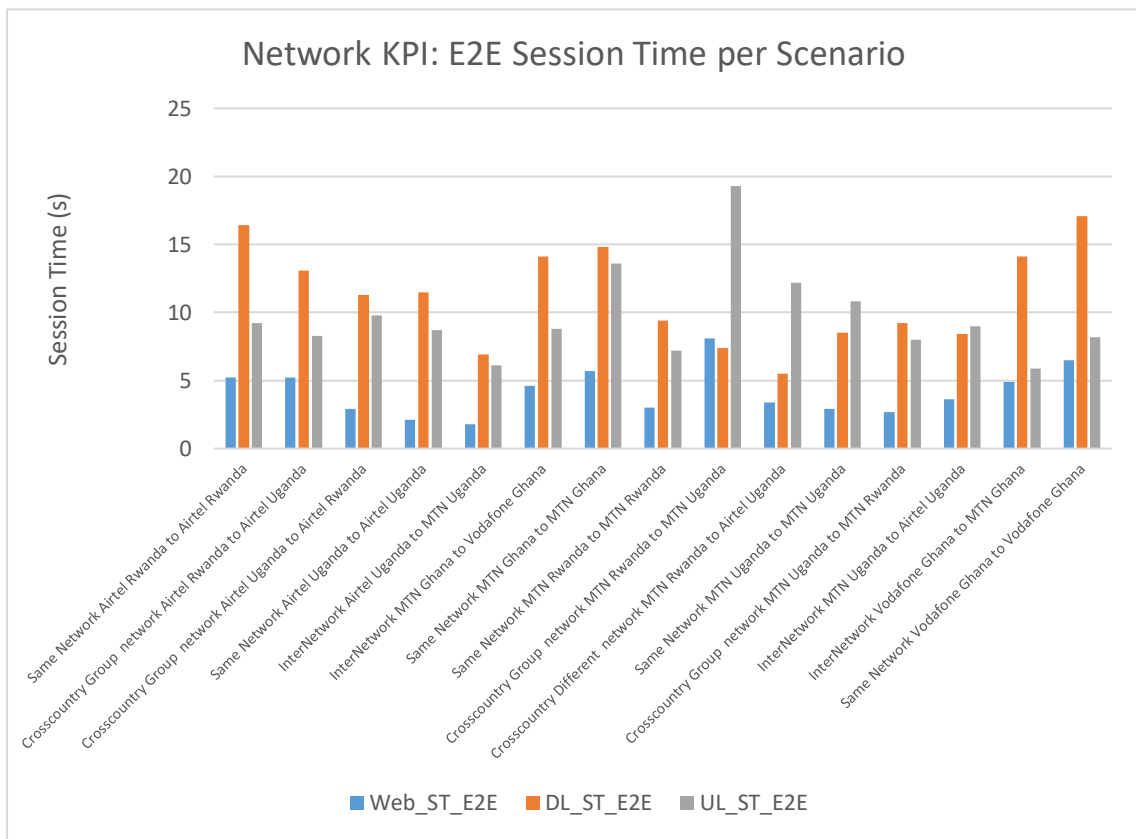
Figure 18 Network KPI: End-to-end Session Time per scenario
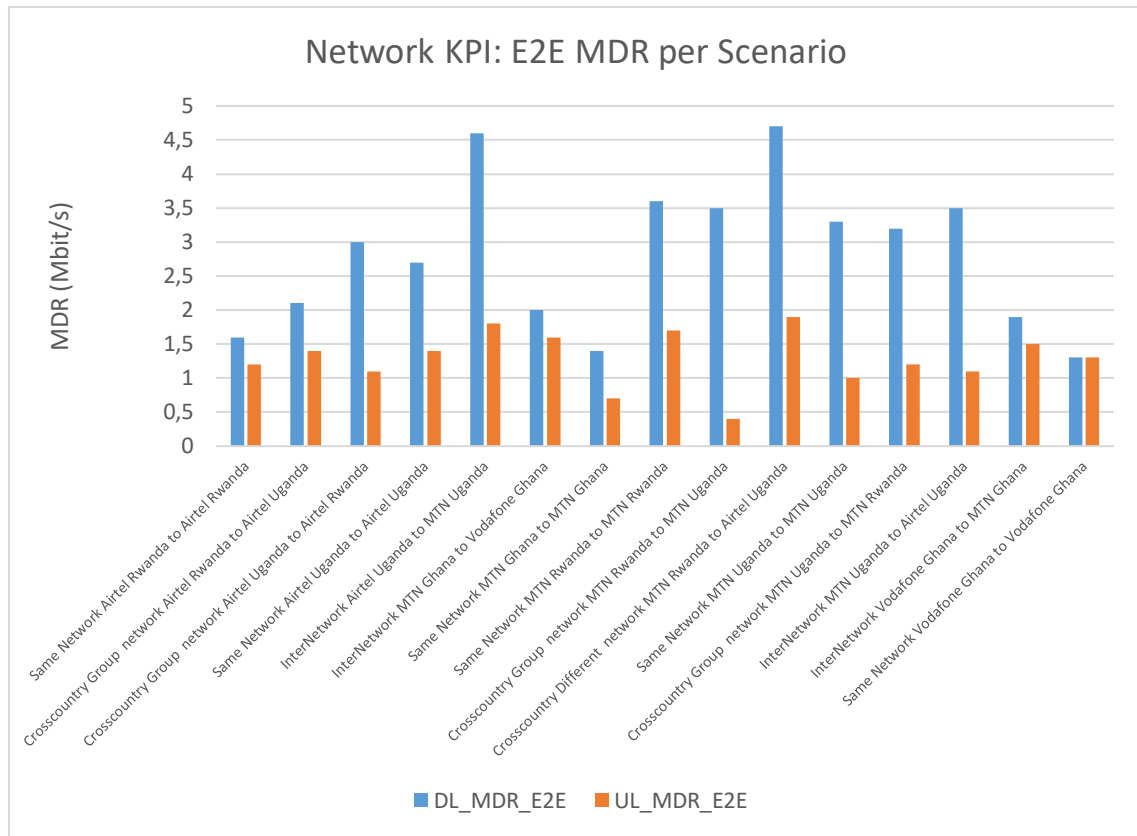
Figure 19 Network KPI: End-to-end Mean Data Rate per scenario

6.8 Combined DFS and network KPI

As outlined in ITU-T Rec. P.1502, the end-to-end performance of DFS from the customer's point of view is both determined by the performance of the DFS-specific infrastructure, and the performance of the transport network. By looking at the correlation between DFS and mobile-network performance, it can be determined if the overall DFS performance is determined or at least influenced by the mobile-network performance.

Likewise, DFS and network KPI data were combined, using the scenario as the common element (joining on scenario). The following tables and figures show the results. It should be kept in mind that due to the limited number of samples, relations have considerable fluctuations and therefore results should be treated as mainly indicative.

Table 12 Combined DFS and network KPI, overview

Scenario	DFS_avg_ET	DFS_Median_ET	DFS_SR	Web_SR	Web_ST_E2E	DL_SR	DL_ST_E2E	DL_MDR_E2E	UL_SR	UL_ST_E2E	UL_MDR_E2E
Cross-country Different network MTN Rwanda to Airtel Uganda	2,7	2	71,2	53,8	3,4	100	5,5	4,7	100	12,2	1,9
Cross-country Group network Airtel Rwanda to Airtel Uganda	8,7	7,4	100	50	5,2	94,2	13,1	2,1	98,1	8,3	1,4
Cross-country Group network Airtel Uganda to Airtel Rwanda	12,7	5,9	64,9	96,6	2,9	77,4	11,3	3	88,2	9,8	1,1
Cross-country Group network MTN Rwanda to MTN Uganda	1,9	1,7	61,3	19,8	8,1	80,3	7,4	3,5	93,7	19,3	0,4
Cross-country Group network MTN Uganda to MTN Rwanda	3,4	2,4	95,1	64,6	2,7	100	9,2	3,2	100	8	1,2
Inter-network Airtel Uganda to MTN Uganda	12,1	9	98,6	94,8	1,8	83,2	6,9	4,6	98,2	6,1	1,8
Inter-network MTN Ghana to Vodafone Ghana	2,8	2,3	91,8	42,9	4,6	79,3	14,1	2	100	8,8	1,6
Inter-network MTN Uganda to Airtel Uganda	2,5	1,8	91,4	47,6	3,6	93,3	8,4	3,5	100	9	1,1
Inter-network Vodafone Ghana to MTN Ghana	2,9	2,7	98,1	48,2	4,9	69,8	14,1	1,9	100	5,9	1,5
Same Network Airtel Rwanda to Airtel Rwanda	9,9	7,2	99,7	35,4	5,2	83,6	16,4	1,6	99,3	9,2	1,2
Same Network Airtel Uganda to Airtel Uganda	11,4	8,8	98,6	74,7	2,1	79,3	11,5	2,7	94,7	8,7	1,4
Same Network MTN Ghana to MTN Ghana	1,9	1,2	92,7	51,9	5,7	51,9	14,8	1,4	100	13,6	0,7
Same Network MTN Rwanda to MTN Rwanda	5,6	1,9	95,3	58,6	3	83,3	9,4	3,6	88,6	7,2	1,7
Same Network MTN Uganda to MTN Uganda	1,8	1,6	92,1	51,2	2,9	93,2	8,5	3,3	100	10,8	1
Same Network Vodafone Ghana to Vodafone Ghana	4,9	4,7	97	69,3	6,5	61,1	17,1	1,3	100	8,2	1,3

The figures in the next subsections visualize DFS vs. network KPI in the form of scatter plots, where the x-axis represents the respective DFS KPI, and the y-axis is used for various network KPI.

The DFS KPI used here is the generic KPI Execution Time (ET) which is, as described in section Transaction model, MSW generic and standard KPI, equivalent to MTCD for practical purposes.

General to these figures: The first group is intended to just show respective value ranges. As each location was used to carry out different scenarios with assumedly different DFS service response time components, it is not be expected to see a global correlation here, i.e. there are cases where the performance of the DFS subsystem clearly dominates the overall performance.

In contrast, the second group of figures where selection by network/operator was made, shows that both DFS and network indicators are in a rather close variation range. With all due caution due to the relatively small number of samples, this supports the assumption that the transport network's performance do have a relation to the DFS end to end performance. Below, some of these cases will be discussed and elaborated in further detail.

6.8.1 All scenarios

For all figures, each data point represents the DFS KPI for one scenario versus the selected mobile-network KPI aggregated for all transactions taken within the time range associated to the corresponding scenario[7].

Figure 20 and Figure 21 show the network KPI Web Browsing end to end Session Time versus the average and the median value of DFS ET. As discussed also in previous sections, the Median is less common to be used in QoS metrics but provides a useful alternative view on the fluctuations of values, in particular where the sample count is relatively small. As can be seen, the picture differs in in details but is basically rather similar. This further supports the assumption that network performance is not the overall dominating component of DFS performance. Details shown in subsequent section will show, however, that on closer look, DFS performance is linked to network performance nevertheless.
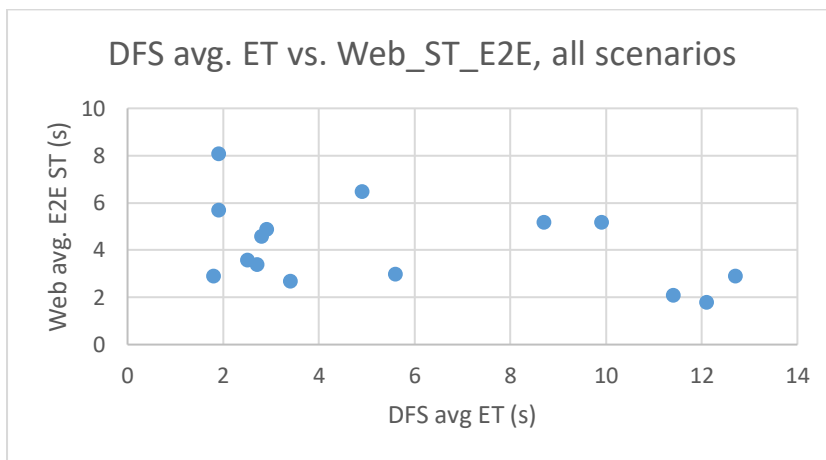
Figure 20 DFS average Execution Time (ET; practically equivalent to MTCD) vs. Web Browsing End to end Session Time
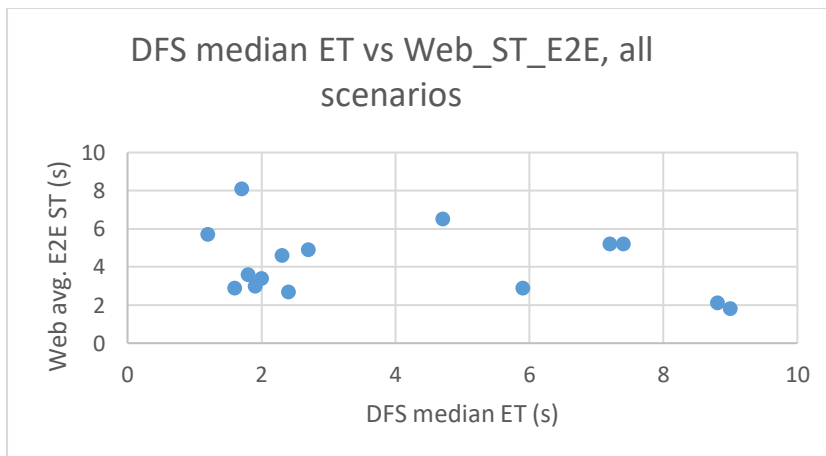
Figure 21 DFS median Execution Time (ET) vs. Web Browsing End to end Session Time

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[7] Please note that in some cases, the ObsTool was not operated over the entire DFS testing time, due to the fact that the location was fixed and to save resources.

Figure 22 and Figure 23 show the DFS ET versus the network KPI "E2E Session time" and "E2E MDR" for the test case http DL (see KPI and validity rules used)[8].
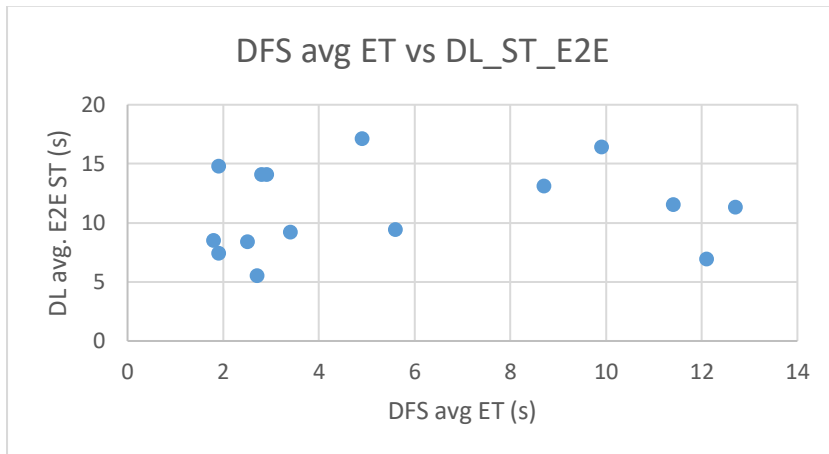
Figure 22 DFS avg. ET vs E2E Session Time for http Download
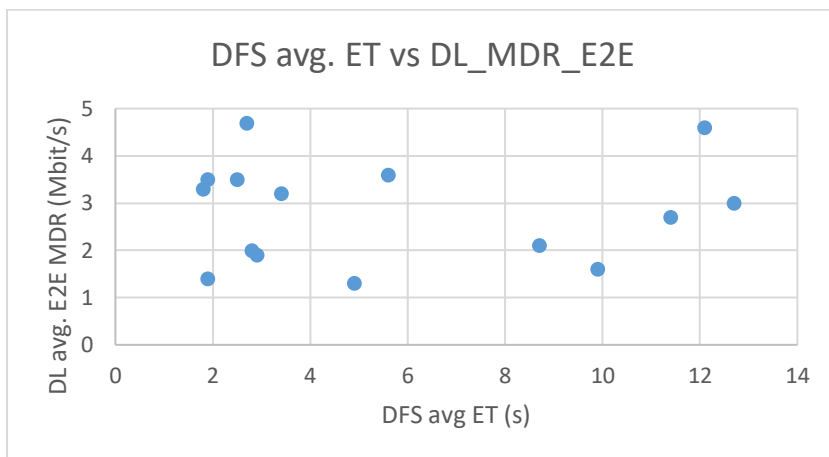
Figure 23 DFS avg. ET vs E2E Session Time for http Download

Finally, Figure 24 shows the network KPI UL E2E ST (see KPI and validity rules used).
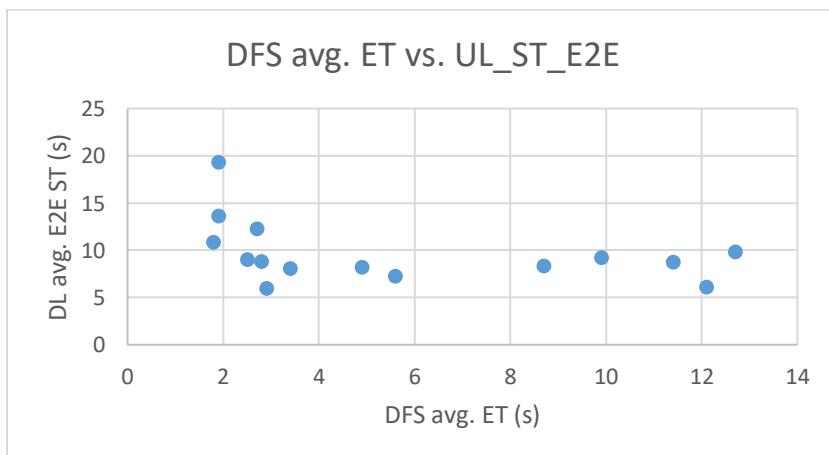
Figure 24 avg. ET vs. network KPI end-to-end Session Time for http Upload

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[8] Please keep in mind that MDR is an inverse indicator, i.e. in case of a correlation, high MDR is expected to correlate to low ET and vice versa.

In conclusion to this introductory view at DFS vs. network KPI: All applicable KPI (Session Time for different use cases as well as MDR for the UL/DL cases) appear to be nearly equally suited, with the DL KPI providing a somewhat higher degree of differentiation. To look closer to the relation between DFS and network KPI, a more specific view is however required, which will be provided in the next section.

6.8.2 Use case scenario by operator/country

In order to look at correspondence between DFS KPI and mobile-network performance, a location-dependent view is required. Assume there are two scenarios S1 and S2 run in the same place with the same A-side mobile network N1 but with different end to end constellations: S1 is sending money from N1 to N2, while S2 sends money from N1 to N3. If the mobile network performance has a significant or even dominating effect on DFS KPI; we would expect similar DFS KPI; if the network performance is not a primary factor, no such similarity would be expected.

The second line of thought is the fluctuation of mobile network performance, i.e. the similarity of mobile network KPI during time periods for scenarios S1 and S2, respectively.

The scatter plots shown subsequently serve both purposes: They allow to compare network KPI for respective scenario-testing time ranges, and to compare DFS KPI (please refer to section MSW generic KPI per scenario for the list of scenarios and respective owner teams/locations).

6.8.2.1.1 Airtel Rwanda
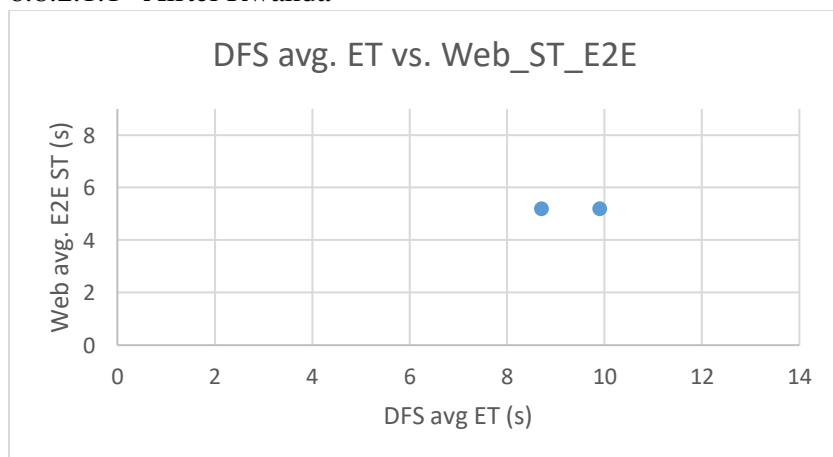
Figure 25 DFS ET vs. Web E2E Session Time, Owner team: Airtel Rwanda
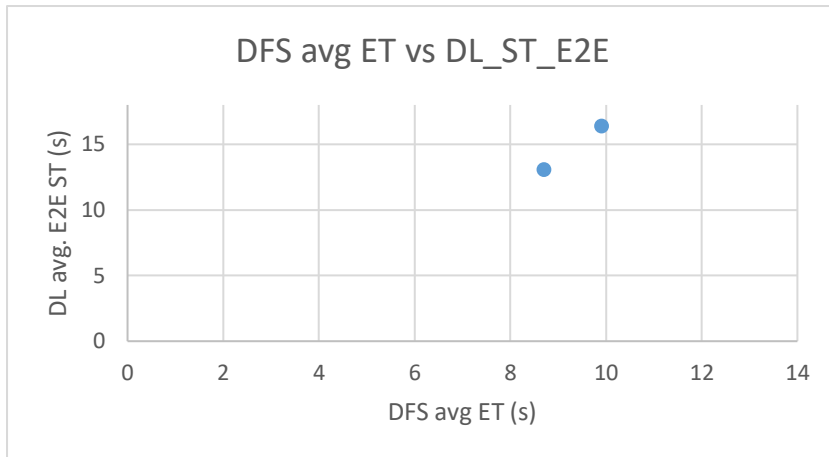
Figure 26 DFS ET vs. DL E2E Session Time, Owner team: Airtel Rwanda
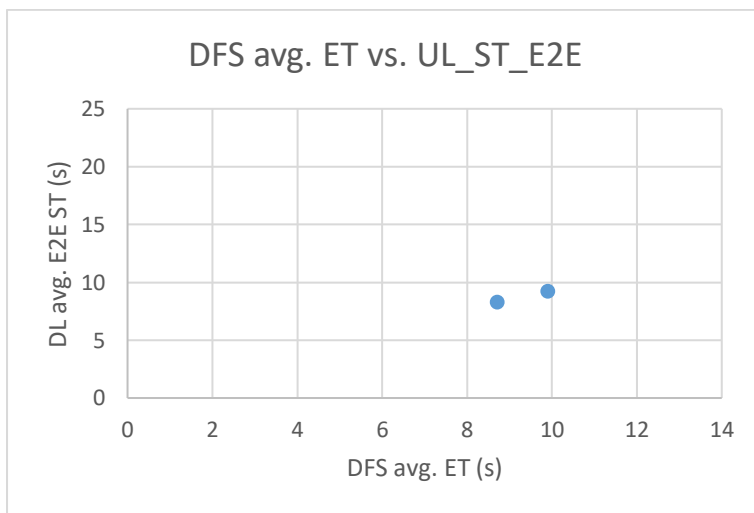

Figure 27 DFS ET vs. UL E2E Session Time, Owner team: Airtel Rwanda
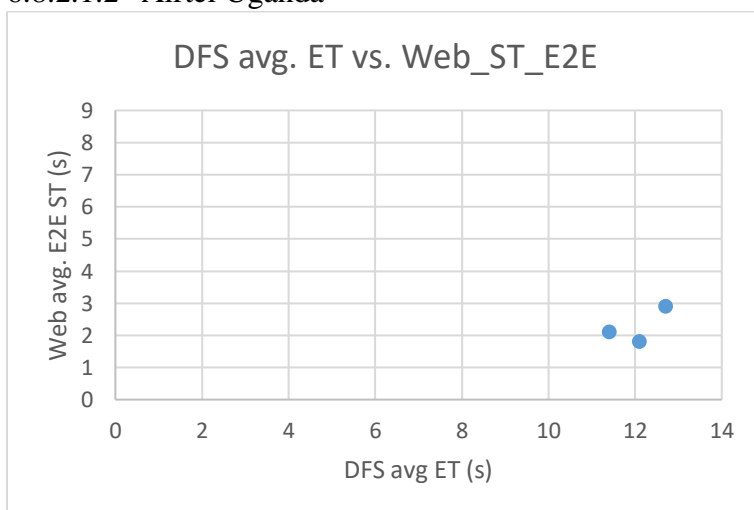
6.8.2.1.2   Airtel Uganda

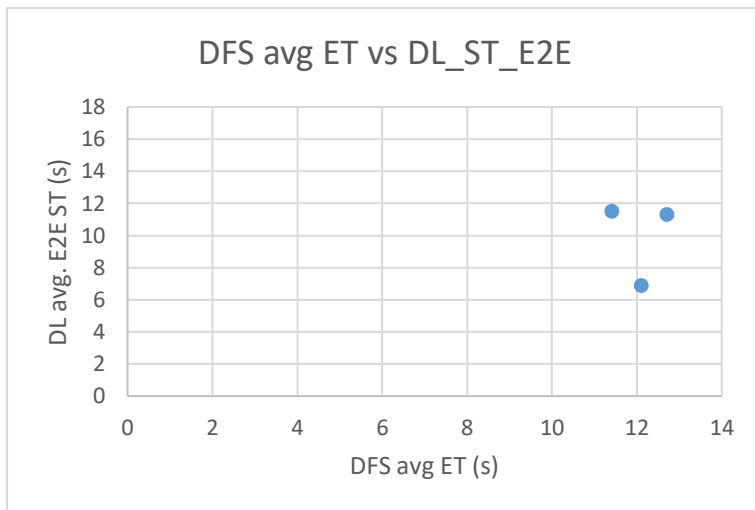Figure 28 DFS ET vs. Web E2E Session Time, Owner team: Airtel Uganda

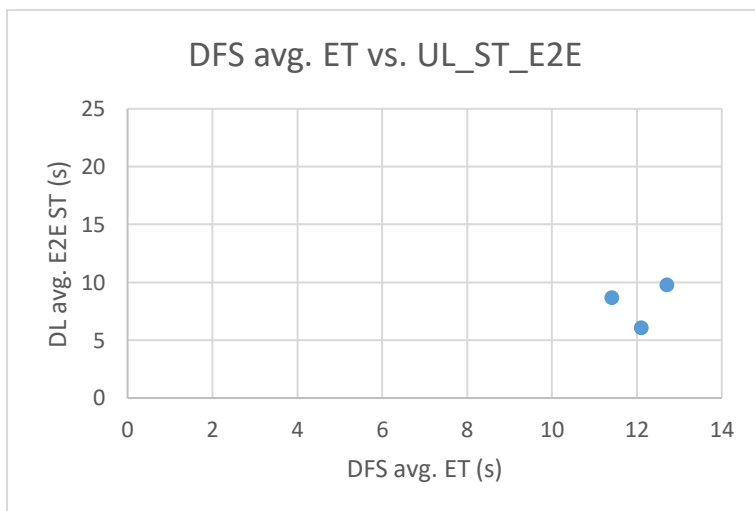Figure 29 DFS ET vs. DL E2E Session Time, Owner team: Airtel Uganda

Figure 30 DFS ET vs. UL E2E Session Time, Owner team: Airtel Uganda
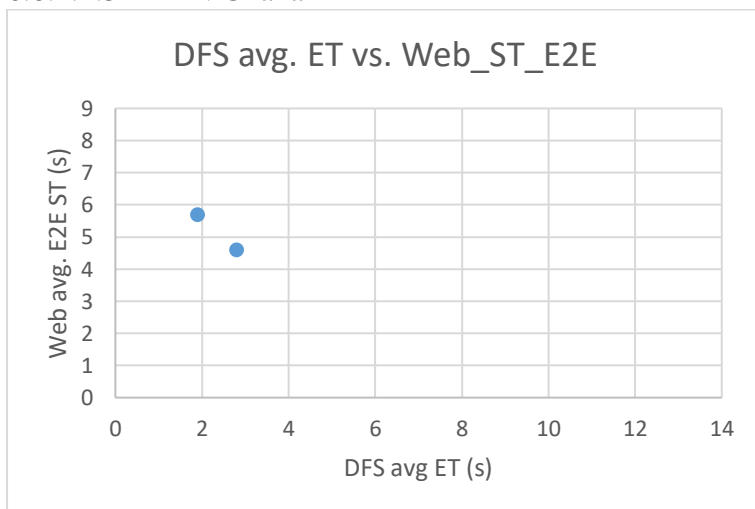
6.8.2.1.3   MTN Ghana

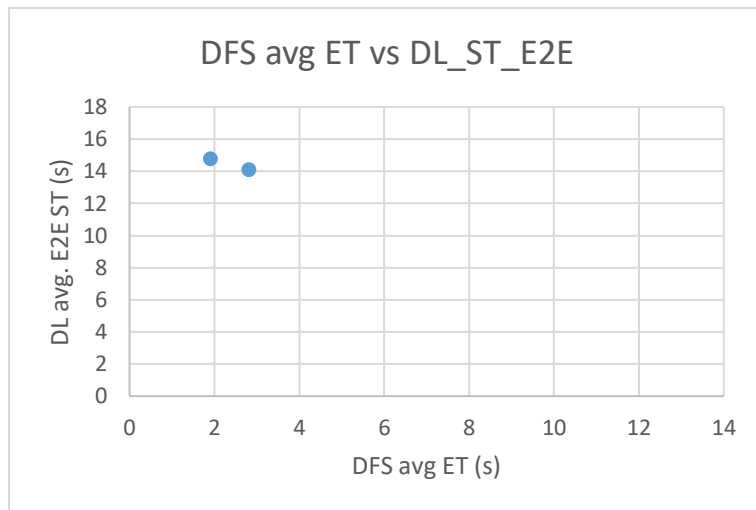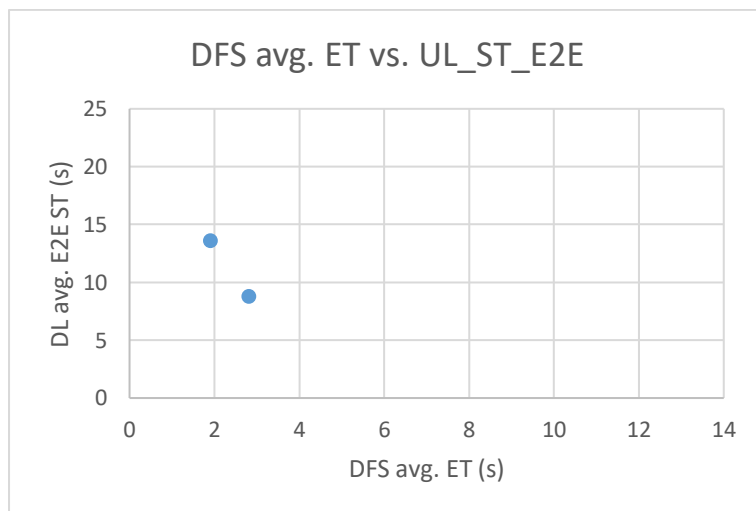Figure 31 DFS ET vs. Web E2E Session Time, Owner team: MTN Ghana

Figure 32 DFS ET vs. DL E2E Session Time, Owner team: MTN Ghana

Figure 33 DFS ET vs. UL E2E Session Time, Owner team: MTN Ghana

6.8.2.1.4 MTN Rwanda

As compared to other operators, it is visible that the spread of data points is larger.

In this case, some of the data came from a team in a different location (Airtel Rwanda).

The data point in question reveals that the x-axis value with DFS ET ~ 6 s had two component sets:

Configuration	Owner Team	Scenario	nSuccess	nTA	avg_ET
MTN Rwanda	Airtel Rwanda	Same Network MTN Rwanda to MTN Rwanda	37	41	14,4
MTN Rwanda	MTN Rwanda	Same Network MTN Rwanda to MTN Rwanda	85	87	1,7

Due to the small data base, this is of course not a proof that network coverage has a significant impact, but it could be a hint towards that direction.
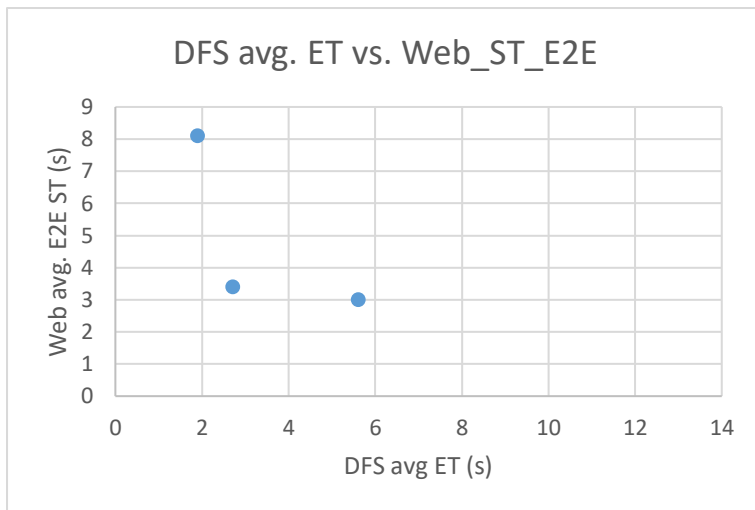
Figure 34 DFS ET vs. Web E2E Session Time, Owner team: MTN Rwanda. As compared to other teams, it is visible that the spread of values is considerably larger. This due to the fact that some of the MTN Rwanda tests were done by the Airtel Rwanda team which was in a different location.
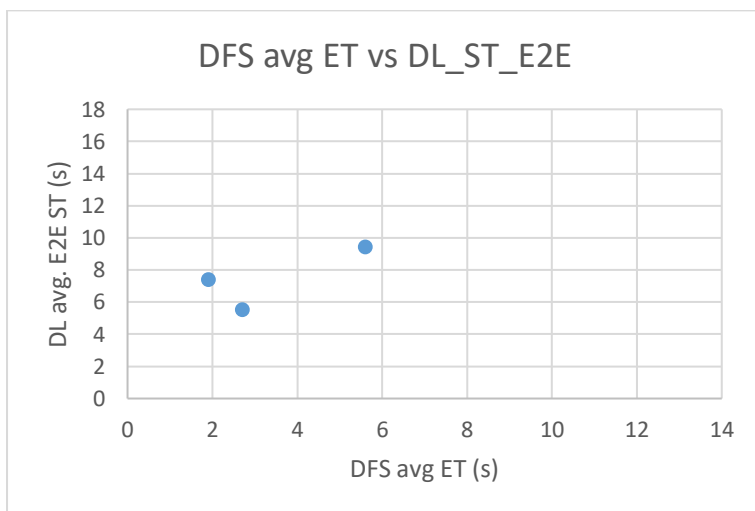

Figure 35 DFS ET vs. DL E2E Session Time, Owner team: MTN Rwanda
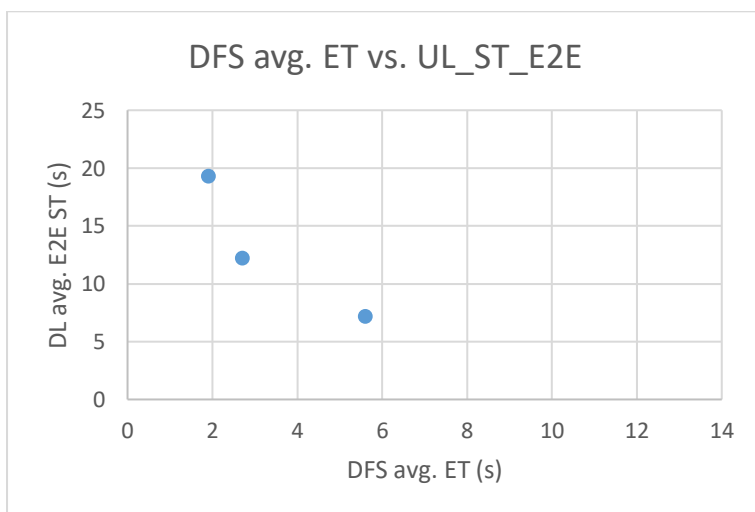

Figure 36 DFS ET vs. UL E2E Session Time, Owner team: MTN Rwanda
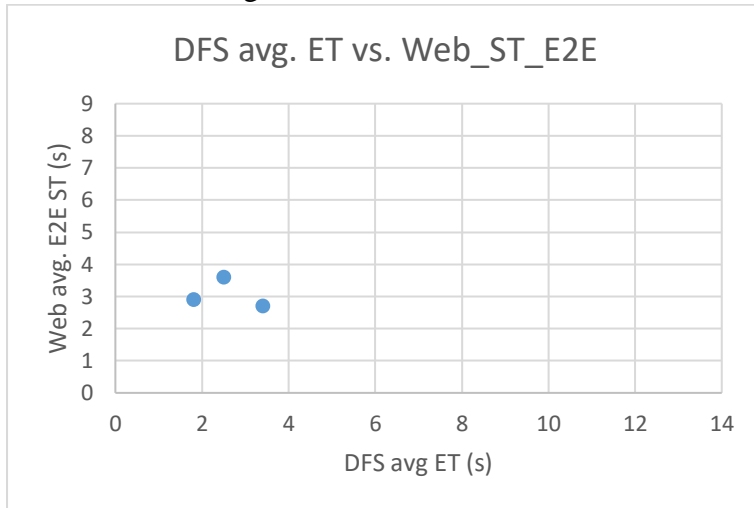
6.8.2.1.5 MTN Uganda

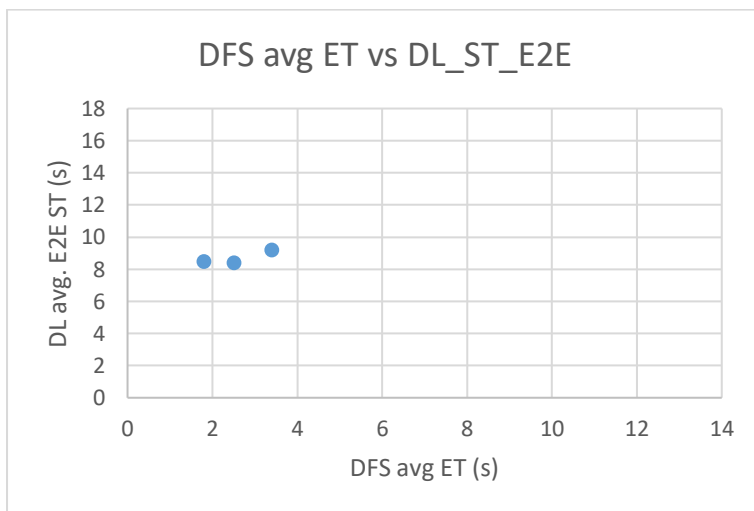Figure 37 DFS ET vs. Web E2E Session Time, Owner team: MTN Uganda

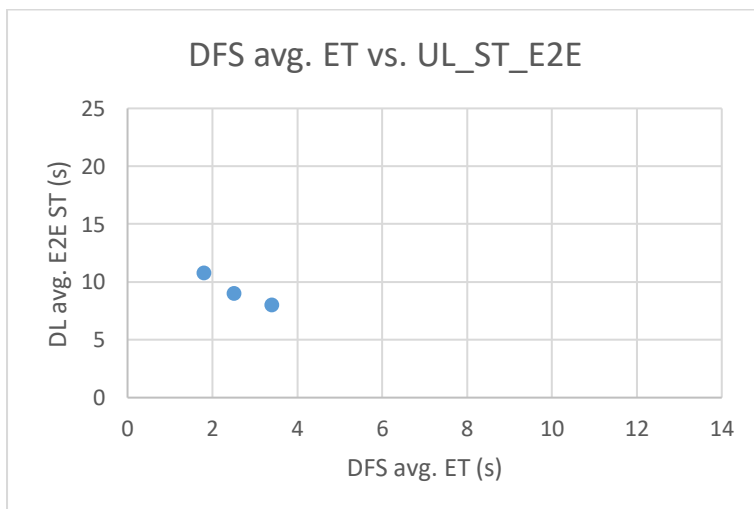Figure 38 DFS ET vs. DL E2E Session Time, Owner team: MTN Uganda

Figure 39 DFS ET vs. UL E2E Session Time, Owner team: MTN Uganda
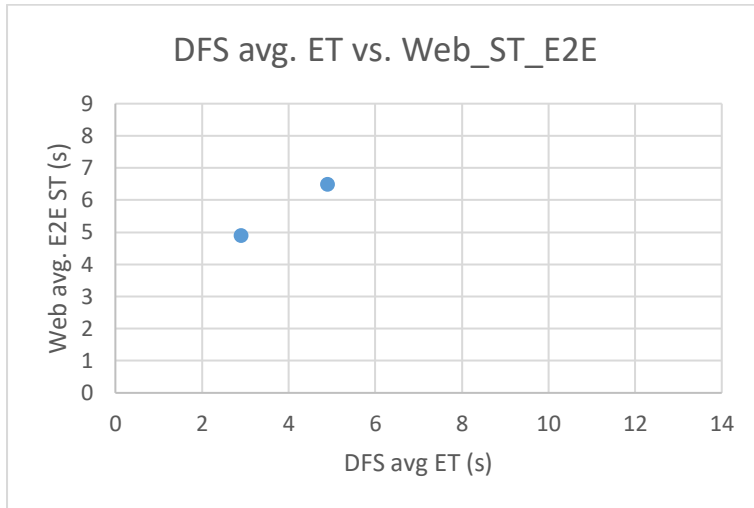
6.8.2.1.6 Vodafone Ghana

DFS avg. ET vs. Web_ST_E2E

Figure 40 DFS ET vs. Web E2E Session Time, Owner team: Vodafone Ghana

DFS avg ET vs DL_ST_E2E
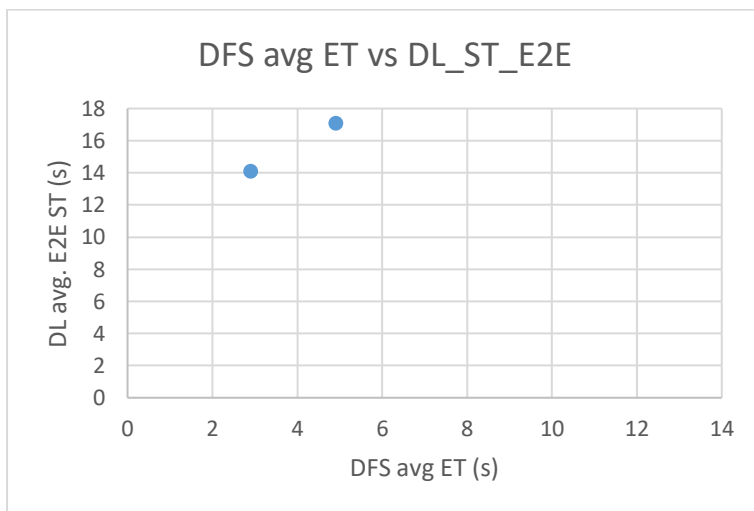
Figure 41 DFS ET vs. DL E2E Session Time, Owner team: Vodafone Ghana

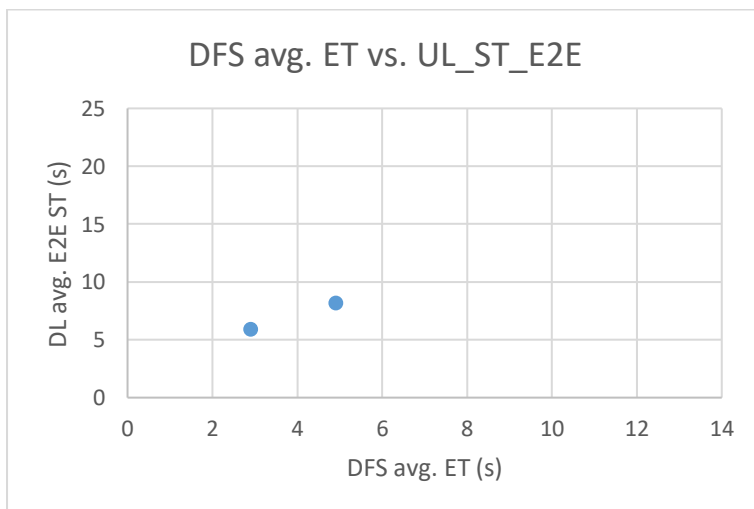**DFS avg. ET vs. UL_ST_E2E**

Figure 42 DFS ET vs. UL E2E Session Time, Owner team: Vodafone Ghana

7 Annex A: Specific procedures used in the project

7.1 Check on devices for files which have not been uploaded

Basically, all data created by the MSW or ObsTool should have been uploaded. Depending on local conditions, it cannot be excluded that some files remain on the device. This can be checked by running the following procedure:

Access to the devices' file system can be done using an external computer or the on-board file manager.

7.1.1 MSW

There are two file paths which should be checked:

File path is internal storage -> FI-Multistopwatch->data

And

File path is internal storage -> FI-Multistopwatch->zipped

7.1.2 ObsTool

The file paths to be checked are

Internal storage ->dfs_observer->data

And

Internal storage ->dfs_observer->zipped

If all data have been uploaded, respective folders should be empty.

Otherwise, please send all files in the respective path (best would be to zip the whole folder and send it as one file) by e-mail or put on the SharePoint.

Please "decorate" the file names or folders to clearly identify the source. The safest way to do that is to use the whole ID of the device (i.e. the MSW ID or the IMEI in case of DFS Observer). In practice, the last 5 characters of the MSW ID or the last 4 digits of the IMEI should be enough.

8   Annex B: Device set-up and training materials

Void, kept for structural consistency. Additional material may be provided as part of the Contribution.

9   Annex C: Network KPI overview from background testing

The following table shows all results from background testing. For selection of KPI and details of computation, see section KPI and validity rules used.

Please refer to section Network KPI Overview for interpretation and visualization of selected elements.

Table 13 Network KPI from background testing. Abbreviations: SR=Success Rate; DL=HTTP DL; UL: HTTP_UL.

Scenario	Web_SR	Web_ST_E2E	DL_SR	DL_ST_E2E	DL_MDR_E2E	UL_SR	UL_ST_E2E	UL_MDR_E2E
Same Network Airtel Rwanda to Airtel Rwanda	35,4	5,2	83,6	16,4	1,6	99,3	9,2	1,2
Cross-country Group network Airtel Rwanda to Airtel Uganda	50	5,2	94,2	13,1	2,1	98,1	8,3	1,4
Cross-country Group network Airtel Uganda to Airtel Rwanda	96,6	2,9	77,4	11,3	3	88,2	9,8	1,1
Same Network Airtel Uganda to Airtel Uganda	74,7	2,1	79,3	11,5	2,7	94,7	8,7	1,4
Inter-network Airtel Uganda to MTN Uganda	94,8	1,8	83,2	6,9	4,6	98,2	6,1	1,8
Inter-network MTN Ghana to Vodafone Ghana	42,9	4,6	79,3	14,1	2	100	8,8	1,6
Same Network MTN Ghana to MTN Ghana	51,9	5,7	51,9	14,8	1,4	100	13,6	0,7
Same Network MTN Rwanda to MTN Rwanda	58,6	3	83,3	9,4	3,6	88,6	7,2	1,7
Cross-country Group network MTN Rwanda to MTN Uganda	19,8	8,1	80,3	7,4	3,5	93,7	19,3	0,4
Cross-country Different network MTN Rwanda to Airtel Uganda	53,8	3,4	100	5,5	4,7	100	12,2	1,9
Same Network MTN Uganda to MTN Uganda	51,2	2,9	93,2	8,5	3,3	100	10,8	1
Cross-country Group network MTN Uganda to MTN Rwanda	64,6	2,7	100	9,2	3,2	100	8	1,2
Inter-network MTN Uganda to Airtel Uganda	47,6	3,6	93,3	8,4	3,5	100	9	1,1
Inter-network Vodafone Ghana to MTN Ghana	48,2	4,9	69,8	14,1	1,9	100	5,9	1,5
Same Network Vodafone Ghana to Vodafone Ghana	69,3	6,5	61,1	17,1	1,3	100	8,2	1,3

Please note that data is shown per scenario but is sorted alphabetically by A side configuration. Therefore, the same network is represented by different sets of data (taken at different points in time, aggregated over the whole testing period for a given scenario. Differences between KPI values for the same network in periods of time are visible. These can be due to statistical fluctuations as well as day-by-day changes in network performance.