How to Structure a Scientific Article

Dr. Hadeel Alghafari

FMEE, Damascus University

Hadeel.alghafari@damascusuniversity.edu.sy

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Agenda

- ✓ The structure of a scientific article
- ✓ How to write a good abstract
- ✓ How to build the introduction section
- ✓ How to organize the related work section
- ✓ How to build the methods section
- ✓ How to organize the results section
- ✓ How to write a good conclusion
- ✓ How to organize the references
- ✓ General advices

The main sections of a scientific article

- Title
- Abstract
- Introduction
- Related Work
- Methods
- Results and Discussion
- References

What should a good title contain?

- The **fewest** possible words
- Words that **adequately** describe the contents of the article
- Words that provide an informative summary to the research
- **Articles with short, catchy titles are better cited**

What is an Abstract and Why is it important?

- Short Summary of the paper (~200 words)
- It should provide an informative summary to
  - Editor
  - Reviewers
  - Readers
- It should **summarize the Entire paper**

Problem | State of art | Novelty | Approach | Results

The components of an Abstract

- The problem and its importance
- The limitations of the previous solutions
- The advantages of the proposed approach
- The method used (technical components)
- Summary of results

How to select Keywords

- Look at keywords of articles **relevant to your research**
- Try to search for these keywords online
- See if the selected keywords return relevant papers (many, few)
- **Avoid** making **too general** or **too narrow** keywords

Abstract & Keywords (example)

Specific

General

Contents lists available at ScienceDirect

Computer Networks

journal homepage: www.elsevier.com/locate/comnet

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Decentralized joint resource allocation and path selection in multi-hop integrated access backhaul 5G networks

Hadeel Alghafari, Mohammad Sayad Haghighi *

School of Electrical and Computer Engineering, College of Engineering, University of Tehran, 1439957131, Iran

Problem & State of art

Novelty

Approach

Results

A R T I C L E I N F O

Keywords:
5 G
Integrated access and backhaul
Mm-wave
Chance constraint optimization
Resource allocation
Path selection

A B S T R A C T

Cell densification has recently been considered as a solution to the high bandwidth demand from the ever-increasing number of connected devices as well as the emerging bandwidth-thirsty applications in 5 G networks. Ultra-dense networks suffer from backhaul bottlenecks. Wireless backhaul connections, especially in the mm-wave bands, have become attractive solutions for the backhaul bottleneck problem. The third-generation partnership project (3GPP) introduced a new Integrated Access Backhaul (IAB) study item in which the same spectral resources are dynamically used for both access and backhaul connections. In densified multi-hop topologies, especially when more than one fiber-linked node exists, it is difficult to solve the problem of resource allocation in a centralized manner. Trying to address this, we propose a distributed stochastic scheme to jointly solve the problem of resource/bandwidth allocation and path selection in a multi-hop multi-path IAB mm-wave 5 G network. First, a Directed Acyclic Graph (DAG) topology formation algorithm is proposed. This algorithm does cell search and performs initial access procedures. It spreads information across child/parent links about the topology. Then, stochastic optimization tools are employed for path selection from the resource perspective. We study the efficiency of the proposed scheme in exploiting resources. Additionally, we explore the effects of stochastic information spread in the topology and also the probability levels on the performance of our scheme. Our analyses show that the proposed distributed scheme yields nearly the same performance as an optimal centralized algorithm in joint resource allocation and path selection tasks. This alternative can take the place of centralized resource management, especially in scenarios where central resource allocation is not possible. In comparison, our scheme outperforms traditional load-based resource partitioning algorithms in the allocation of resources by up to 20%. Results also show that our scheme exploits the resources similar to what an instantaneous load-based strategy does, but without the need for excessive signalings.

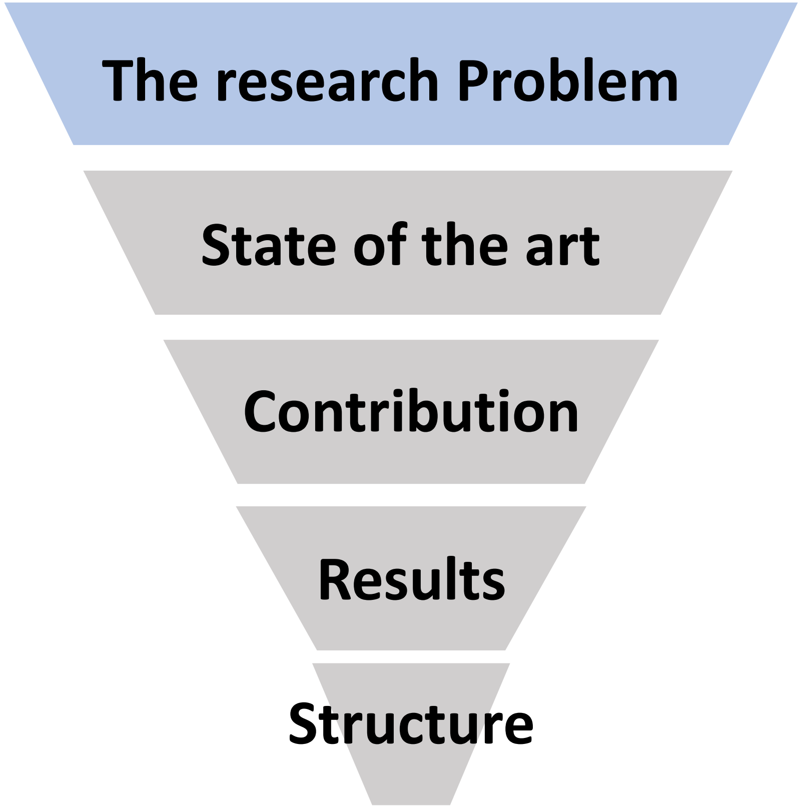
What is an Introduction and Why is it important?

- The first section of the paper
- The story of the paper (from general to specific)
- Makes the first impression of the quality of the paper
- Either makes or clarifies doubts about the importance and the novelty
- Affects the likelihood of acceptance/rejection of the article
- Length may vary (~3 columns)

The general structure of the introduction section (1/5)

The research problem

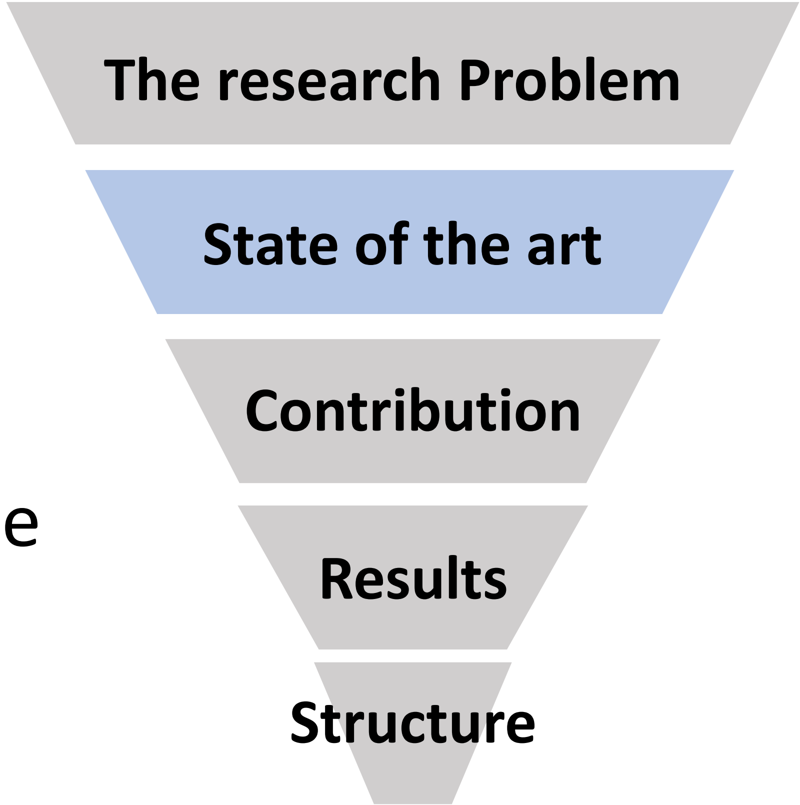
- Start with a big problem
- Scale it down to the addressed problem
- Convince the reviewer with your problem
    - Important problem
    - Current problem



The general structure of the introduction section (2/5)

State of the art

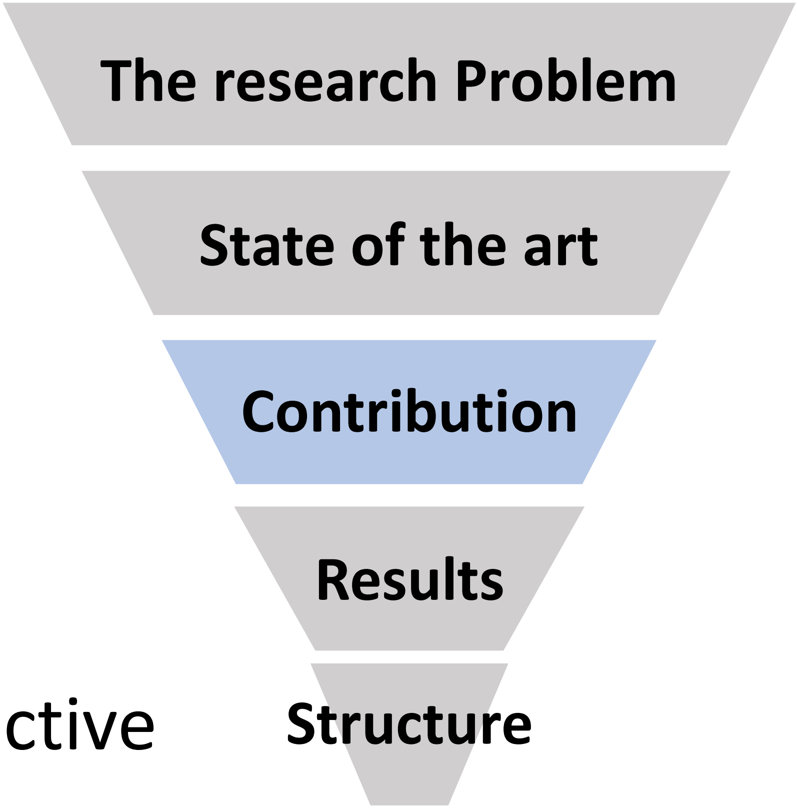
- Summarize what has been done related to your issue
- Why what has been done is not sufficient?
- Make a good case of your paper compared to the state of the art



The general structure of the introduction section (3/5)

Contributions

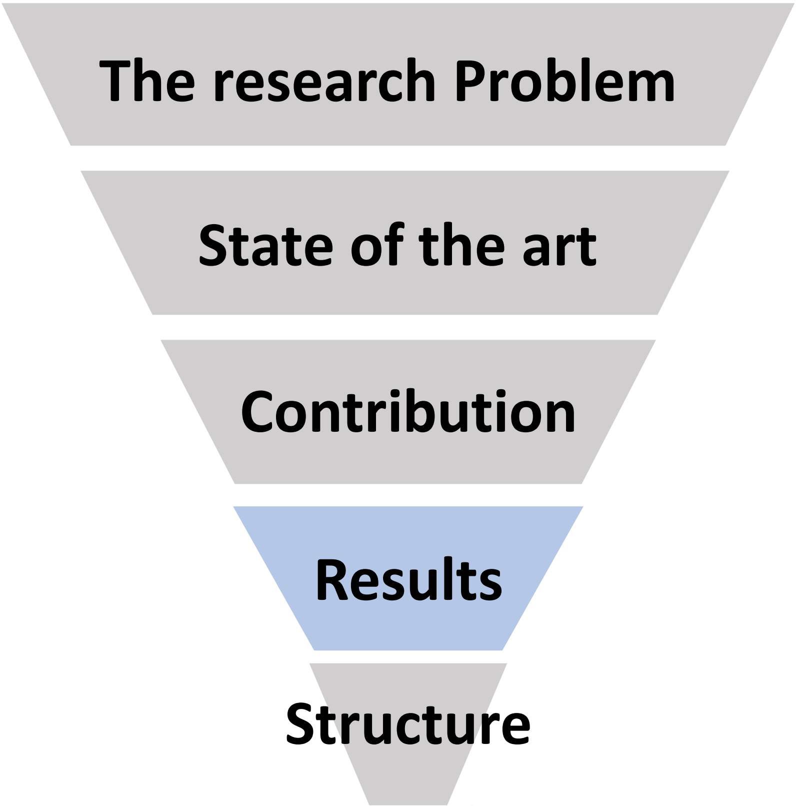
- What are **<u>your solutions to the problem</u>**
- Give sufficient description to the reader
- Mention the **<u>used components and tools</u>**
- Blend it all together
- Guide the reader/reviewer to make a good perspective about the proposed approach
- May be added in details at the end of related work section



The general structure of the introduction section (4/5)

Results

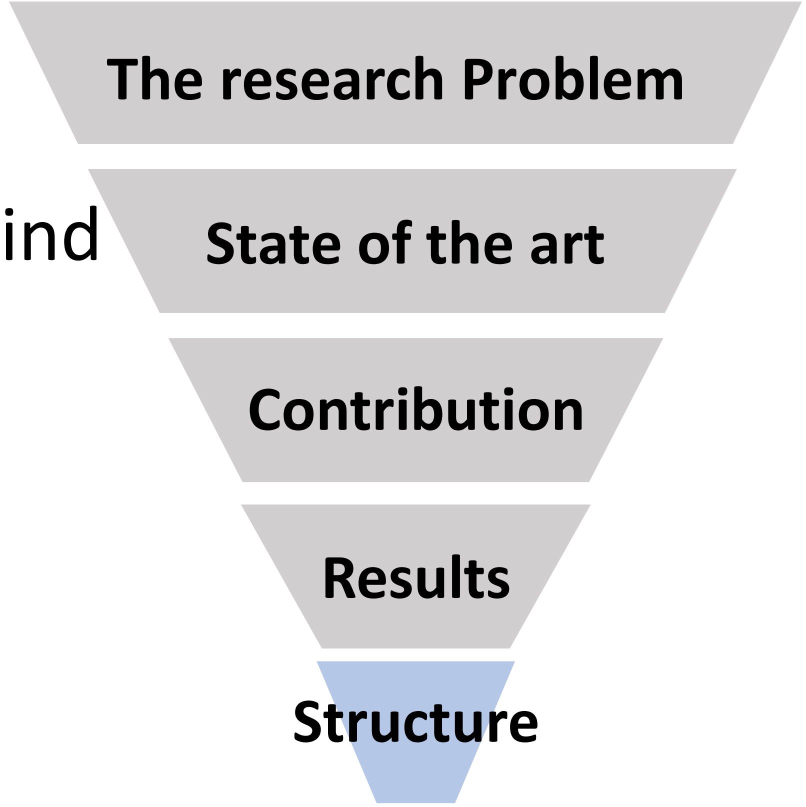
- How are you going to **validate** your proposed approach?
- What do you use for **results discussion**?
  - Simulations
  - Real Experiments
  - Special tools
  - Etc.
- Mention if a **comparison** with others' results exists in your work
- Show that the validation is done



The general structure of the introduction section (5/5)

Structure

- Conclusion of the introduction section
- List the main contributions to stay in reader’s mind
  - (optional)
- Summarize the sectional structure of the paper
  - (optional)



Introduction (example)

Structure

including the donor nodes. However, it can only connect to one donor at a time given a specific route. An IAB mesh-architecture was also suggested by Zhai et al. in [24], in order to enhance the performance of the network. Fig. 1 shows an example of the two IAB standard topologies. In addition to accommodating adaptive topologies, maintaining reliability, high capacity and low end-to-end delay, IAB networks must support multi-hop multi-path self-backhauling to enhance coverage and range [22]. With the appearance of this study item, many research problems surfaced. Resource allocation and path selection are the main issues in IAB networks. In DAG topologies, it is difficult to do resource allocation and path selection in a centralized manner, since IAB nodes may have routes to more than one donor, which might belong to different operators or be far away from each other and have no common communication channel. Hypothetically speaking, one can add a central node which is connected to all donors in topology, and solve the abovementioned problem in a centralized manner. However, this is unlikely to happen since there may be different operators handling the donors. Even if they belong to the same network, this approach results in high signaling overhead and increased latency. Adopting distributed algorithms for resource allocation and path selection in DAG IAB topologies, can potentially lower the overhead and promote the performance.

The rest of this paper is organized as follows: In Section 2 we present an overview to the works on integrated access backhaul, resource allocation and path selection problems. In Section 3, we discuss in detail the network formation as well as the assumptions. In Section 4, we describe the system model and the problem formation. We also present our proposed distributed stochastic optimization problem in this section. In Section 5, we solve the proposed stochastic optimization problem by transforming it to its deterministic counterpart and adopting a linear solving approach. The results and evaluations are reported in Section 6. We also compare our algorithm with an optimal centralized algorithm and other load-based resource partitioning algorithms in this section. Finally, the paper is concluded in Section 7.

Sun et al. [30] jointly optimized the power allocations and backhaul link rate control in a downlink non-orthogonal multiple access (NOMA) system for space information networks (SIN). Their proposed scheme was subjected to long-term average and short-term peak constraints of the communication resources on high throughput satellite (HTS), including power and storage space.

The presence of mm-wave also has motivated lots of researches related to self-backhauling issues. For instance, routing, path-selection, user association and resource allocation become more critical because of the resulted backhauling problem. Regarding path selection, Vu et al. [31] adopted a centralized approach in order to select the best paths and allocate rates over multiple paths, subjected to latency constraints and objected to maximize the network utility in a multi-hop mm-wave self-backhauled scenario. Ma et al. [32] presented a multi-path source routing protocol in self-backhaul 5 G mm-wave networks. Their protocol relies on the remaining bandwidth of adjacent nodes, and the route discovery tries to meet the bandwidth requirements of the source node.

Related to user association, Jian et al. [33] introduced a joint optimization framework by formulating an application aware user association with multiple dual connectivity modes, as well as resource allocation strategy as a Mixed Integer Linear Program (MILP) by considering the backhaul constraints in 5 G heterogeneous networks.

Concerning with resource allocation, Kulkarni et al. [34], and Nguyen et al. [35] studied the problem of resource allocation in a self-backhauled time-slotted mm-wave two-tier heterogeneous network. Scheduling schemes for time division duplexing (TDD) in [34], and Reverse TDD in [35] between access/backhaul and Up/Down links were analyzed. A constant division scheme depending on a constant fraction, and two dynamic splitting fractions were adopted for bandwidth partitioning between access/backhaul UL/DL in [34,35], respectively.

IAB study item also motivated researchers from different angles. Polese et al. [36] evaluated the end-to-end performance of the IAB architecture through system-level full-stack simulations in terms of experienced throughput and communication latency. The number of deployed fiber linked nodes is one of the research problems relates to

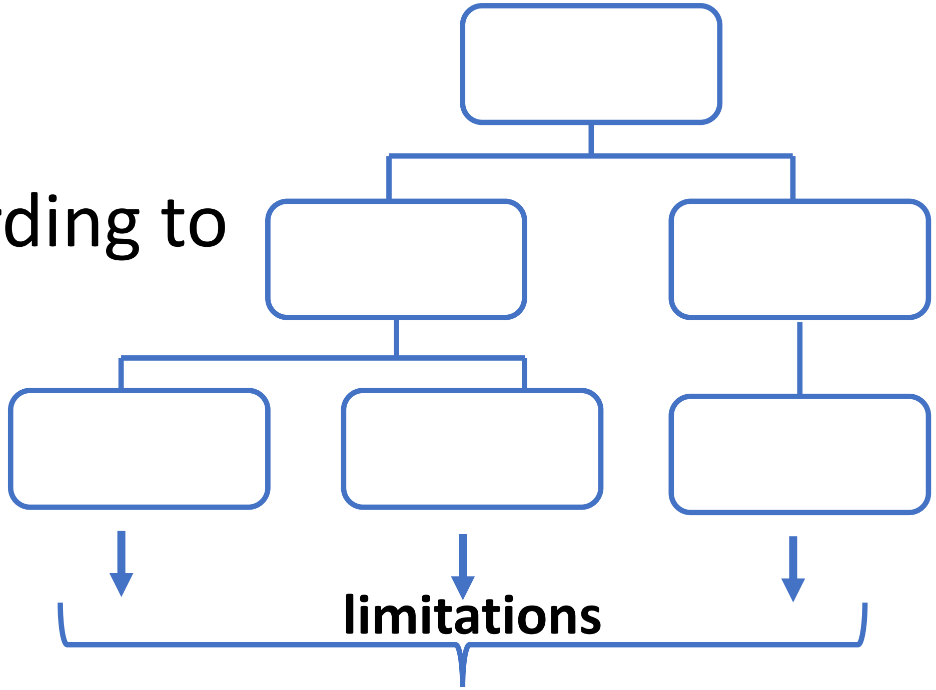
How to build a good Related Work section (1/3)

- Select good and **relevant works**
  - Use tools (IEEE Explore, ACM, Google Scholar, etc.)
  - Search efficiently for related keywords
  - Search for different contextual with same problem and/or solutions
- Select to cite **the most relevant and important**
- Select to cite the papers published **in the best venues**
- look for:
  - The ranking of the conferences/journals
  - The number of citations of the papers
  - The year of publication

How to build a good Related Work section (2/3)

Building a Taxonomy

- **<u>Provide a taxonomy</u>** of the related work
- Organize the selected **<u>papers in groups</u>** according to
  - Assumptions
  - System Models
  - Type of problems
  - Adopted solutions and tools



- At each leaf, show:
  - **<u>The motivation and novelty of your work with respect to others' works</u>**

How to build a good Related Work section (3/3)

Common Mistakes

- Setting false expectations
- Lack of organization and focus
- Missing new/important papers
- Missing important venues

Related Work (example)

2. Background and related work

Learning (RL) to learn the scheduling policy while minimizing the delay. Polese et al. [45] studied different greedy decentralized hop-by-hop link selection strategies (highest-quality-first (HQF) policy, wired-first policy (WF), position-aware policy (PA)). Authors also suggested a wired bias function which gives wired nodes priority on other candidates and helps in decreasing the number of hops. Liu et al. [46] studied the resource allocation problem in a user provided network (UPN) formed by D2D links under IAB 5 G network, considering the fairness between users. They formulated the problem as a cooperative game. They designed a centralized algorithm to get the Nash bargaining solution, then they decomposed the problem into subproblems and solved it by an iterative algorithm. Fouda et al. [47,48] suggested taking advantage of unmanned aerial vehicles (UAVs) by considering them as IAB nodes. They jointly optimized the user and base station associations, and the downlink power allocations for access and backhaul links, by proposing an interference management algorithm objected to maximize the network sum rate.

At the network model side, most studies adopted stochastic geometry tools in modeling hierarchical HetNets [49,25,50,16,18,51], where Poisson Point Processes (PPP) were adopted to model the network part.

The majority of previous studies focused on mono-layer networks (i. e. one macro cell overlaid with small base stations in its coverage) and adopted centralized algorithms. Some even considered fix splitting of resources between access and backhaul links. As mentioned previously, resource allocation and path selection issues cannot always be dealt with in a centralized manner, especially in multi-hop DAG IAB topologies. In our study, we aim to jointly solve the problem of resource allocation and path selection for multi-hop multi-path DAG IAB topologies with multiple donors in a distributed manner. We present, to the best of our knowledge, the first fully decentralized scheme to jointly solve the

IAB topology is establis
chronization signals in 5 G r
some similarities with prior
[53]. IAB nodes perform t
cedures that a User Equipm
cedure, cells periodically tra
These signals help other nod
cells to connect to. Moreov
recognize the presence of o
and directions of arrivals of
In our model, we take a
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everyone in its range of its
layer 0 sends SSBs to other n
in Γ directions. By receiving
boundary and synchronize
are at the first layer of the to
inform other nodes in their
haul link) to the fiber-linked
also done by sending SSBs th
first layer of the topology.
conclude that they are at the
donor. They are also synch
This procedure continues u
(edge nodes), as shown in
nodes' presence and learn
signal arrival, can specify i
topology formation results
making a dependable netw

3

ng resource allocation, the total bandwidth W is
parts, ηW for backhaul and $(1-\eta)W$ for access,
d $\eta \in [0,1)$. The total access bandwidth is shared
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ndwidth is divided by one of the three mentioned
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AB topology constructed by max-min spectral ef-
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Grouping previous works

Limitations and Novelty

What is the Methods section?

- Describe exactly **what you did, and how**
- How was the study carried out and analyzed
- Include all important details so that the reader can repeat the work
- A method described for every result you intend to include
- Start by specifying the design of the study
- **Build it depending on your research**
  - Experimental, Analytical, Technical, etc.

Methods

What should the Methods section include? (1/6)

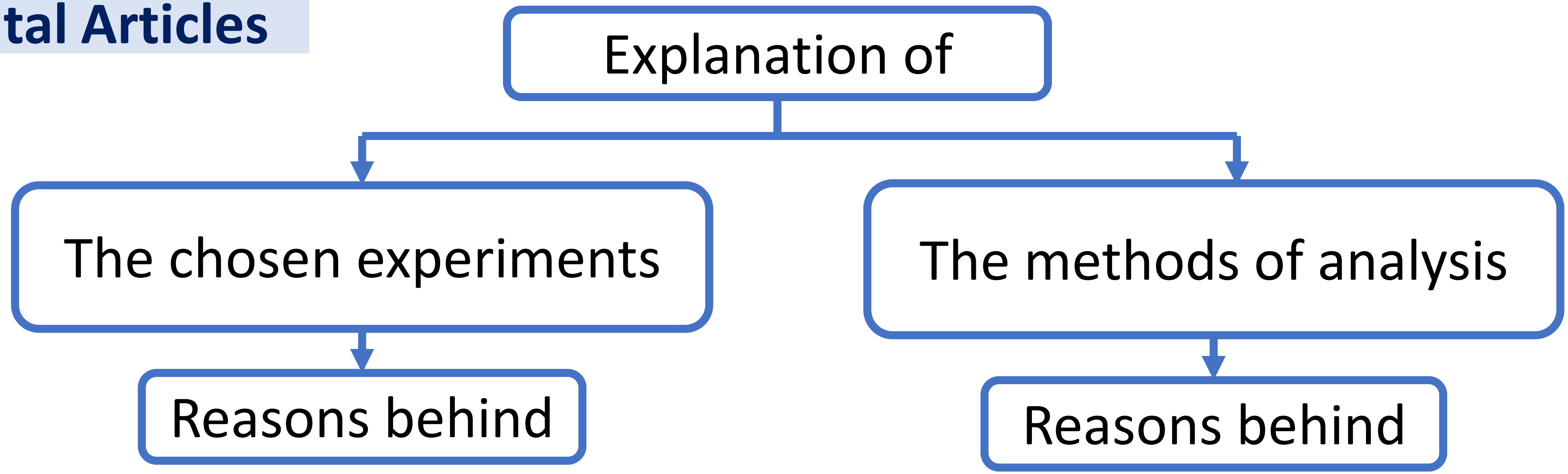
Experimental Articles

Description, in a chronologically organized protocol, of

- The used Materials
  - Site/samples
- Preparation and Measurements
- Achieving the experiments

What should the Methods section include? (2/6)

Experimental Articles



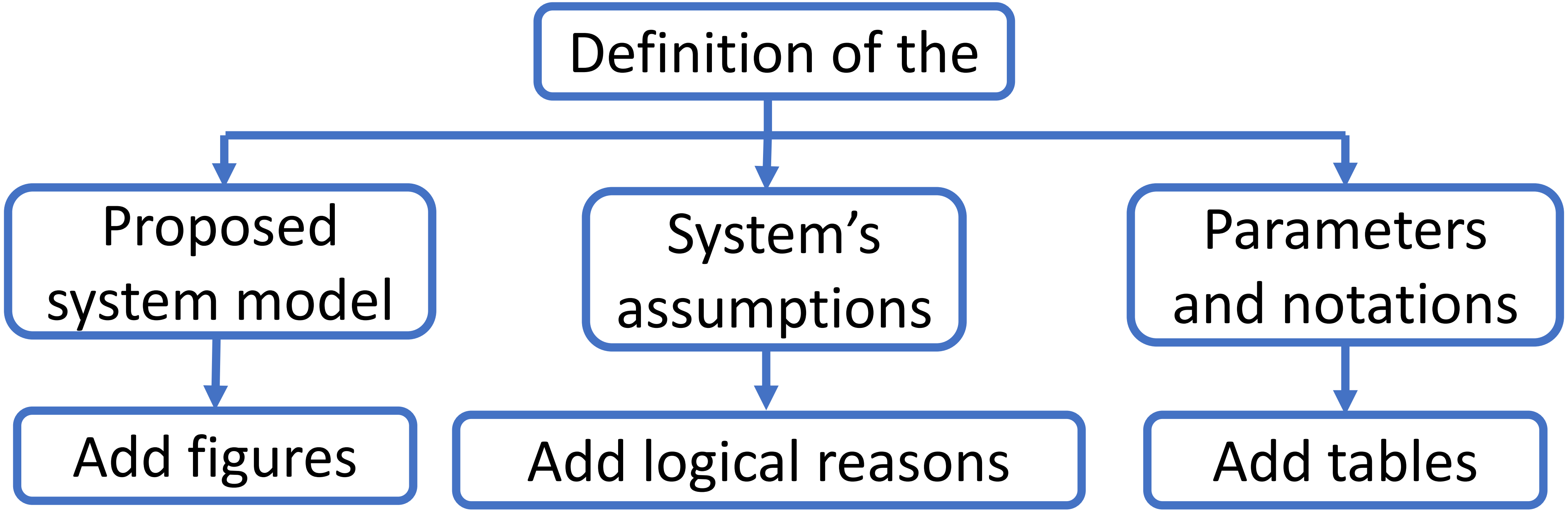
- List the methods in the same order as they appear in the results section
- Methods should be organized from most to least important
- Methods section may include several subsections

Methods

What should the Methods section include? (3/6)

Analytical and Technical Articles

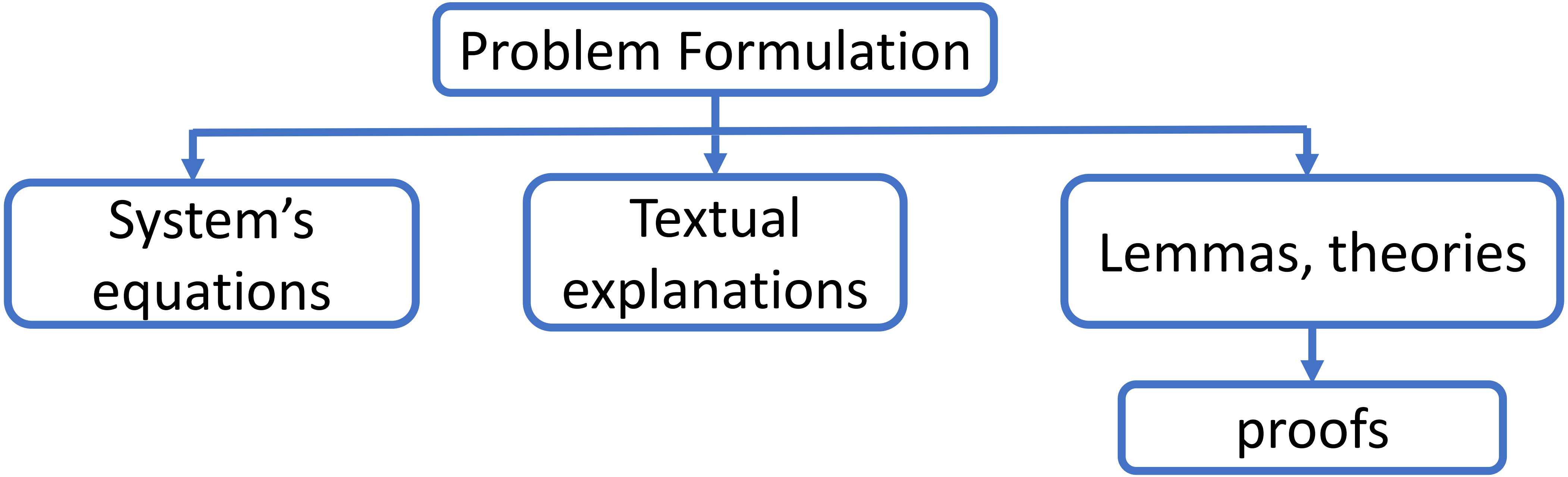
- **<u>Definition of the proposed System Model</u>**



What should the Methods section include? (4/6)

Analytical and Technical Articles

- **<u>Formulation of the problem you are addressing</u>**

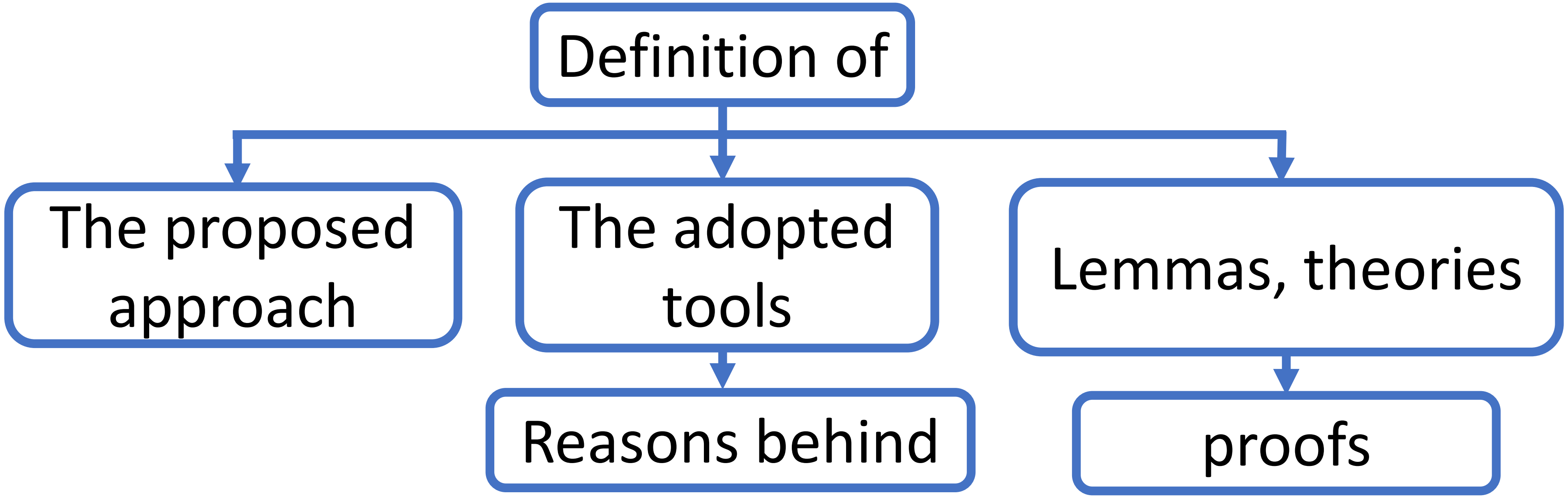


Methods

What should the Methods section include? (5/6)

Analytical and Technical Articles

- **<u>The proposed solution of the formulated problem</u>**



Methods

What should the Methods section include? (6/6)

Analytical and Technical Articles

- **The proposed solution of the formulated problem**
  - Define the proposed approach and the adopted methods
  - Separate different methods into different paragraphs
  - Achieve the approaches
  - Use **Figures, algorithms and flowcharts** for simplifications
  - Prepare the needed data and samples (can be included at results)

Methods (example)

with index s) which make decisions on the allocation of resources. we

$$\sum_{\forall p_h^{n-1} \in \Phi_{f_s^n}} \sum_{\forall p_e^r \in \Xi_{(f_s^n)}} \sum_{\forall r_{p_e^r}(p_h^{n-1}, f_s^n) \in R_{p_e^r}(p_h^{n-1}, f_s^n)} \left(\omega_{f_s^n}^{p_e^r}(p_h^{n-1}, f_s^n)_{r_{p_e^r}(p_h^{n-1}, f_s^n)} \right) \leq B \quad (9)$$

Third, the requests on all the links with the parents of a specific parent must not exceed the backhaul capacity of that parent (which is presumably half of its total capacity, or $0.5B$), e.g. the parent $p_q^{n+1} \in \Omega_{(p_i^k)}$ and all its parents $\forall p_b^{n+2} \in P_{p_q^{n+1}}$ through the links $\forall(p_q^{n+1}, p_b^{n+2}) \in R_{(p_i^k)}$. In this process, other children's requests from these links must be taken into account. These requests are modelled as random variables (see (4)). This constraint is demonstrated in Fig. 5(d) by ($\partial_2 < 0.5B - y_{(p_q^{n+1})p_c^n}$), which shows how the sum of requests from node p_i^k, on behalf of edge node p_e^r, from all the parents of the parent p_q^{n+1} (which is notated by ∂_2), does not exceed the total backhaul capacity of node p_q^{n+1} (which is $0.5B$), while taking into account the requests of other children from these parents as random variables (such as the request of the child p_c^n, $y_{(p_q^{n+1})p_c^n}$). The fourth constraint guarantees that the LHS of the second and the third conditions remain equal, which means that the access and backhaul requests for resources from a node must be equal (see (5)). This constraint is shown in Fig. 5(e) by ($\partial_1 = \partial_2$), which shows that the access and backhaul requests of node p_i^k, on behalf of edge node p_e^r must be equal. The defined optimization problem Eqs. (1)–((6)) holds true for both edge and middle nodes, while for edge nodes, we replace the requested resources by p_e^r (to be $x_{p_e^r}(link)_{route}$ instead of $x_{p_i^k}^{p_e^r}(link)_{route}$). Moreover, since edge nodes have no IAB children, constraint (2) is

p_q ... on behalf of all edge nodes (i.e. $\forall p_e \in \Xi_{(p_i^k)}$), must not

i.e. B. We assume in our study that a donor node has the same capacity as the other nodes, but unlike them, the whole capacity can be dedicated to access links, since a donor is backhauled by fiber links. However, our approach is generic and in case it is necessary, this assumption can be relaxed and donors with larger capacities (more than B) can be considered.

5. Solving the optimization problems

All the proposed optimization problems are linear programs. However, the optimization problems of edge and middle nodes depend, in their constrains, on random variables (e.g. $y_{(p_m^n)c}$), thus they are stochastic optimization problems [57,58].

In order to solve a stochastic optimization problem, we have to find its Deterministic Equivalent Problem (DEP) [59]. A common practice in stochastic problems is to use the expected value of random variables [60]. Therefore, in the previously proposed algorithm, we can say that a node, while solving its own optimization problem, may consider the bandwidth requests of other children from the parents they share, to be the expected bandwidth values these parents have previously allocated to those children. For example, the amount of resources a child (e.g. p_c^{n-1}, or simply c), requests from a parent (like p_m^n) from p_i^k point of view (assuming that node p_i^k is solving its problem), equals the expected value of the resources this parent has previously allocated to this child, that is, $y_{(p_m^n)c} = \lambda_{(p_m^n)c}$. This way, we can derive the deterministic equivalent problem of the stochastics one. We call this approach the "proposed expected value-based algorithm", since it depends on the expected values of allocated bandwidths.

We also suggest in our study a chance-constraint method for solving

Optimization tools

Proposed approach

How to organize the Results section (1/3)

- Logical sequence representation of **the main findings** of a study
- The main findings without bias or interpretation
- Findings from experiments described in the Methods section
- Findings that **give answers to the research questions**
- Results of the statistical analysis

How to organize the Results section (2/3)

- A comparison with other findings in other publications (if needed)
- **Avoid** just telling a string of data
- Data and results are presented in **figures, tables, charts, and graphs**
- Give the real picture of what you did
- **Dedicate a paragraph/subsection for each main finding**
- Tell the story of the findings.
- **Visualization is important** (use tools, such as visio)

How to organize the Results section (3/3)

❖ **For each main finding, answers the following questions:**

1- Why are you performing the analysis?

- The reason behind doing it
- What is expected from doing it

2- What did you find?

- Fundamental results
- Give logical evidences behind these results

3- Why does a finding matter, and how?

4- What does a finding mean?

- In the Discussion section, if separated
-The conclusions of your study

Results (example)

N_7 (which is $0.21B$ and denoted by λ_{74}), it concludes that it can request for $0.4B$ from N_4's capacity (considering $\alpha = 0.1$, and depending on constraint (14)). Regarding this path, N_8 also shares F_2's capacity (through the link between N_4 and F_2) with the nodes N_9, $F_{2access}$, and N_7. Bandwidth expected values of these links, as shown in Fig. 8, are $0.22B$, $0.25B$ and $0.21B$, respectively (denoted by λ_{952}, $\lambda_{2access}$, λ_{74}). Thus, N_8 can request for $0.5B$ of F_2's capacity (depending on constraints (14) and (15) and $\alpha = 0.1$). As a result, node N_8 can not request from $path_{842}$ for more than $0.21B$, since this path is limited by the capacity N_4 provides. The same can be said about $path_{852}$, where it is limited to the capacity of N_5, and N_8 shares this path with node N_9. The expected value of the bandwidth allocated for the link L_{952} (which is a combination of two links L_{95} and L_{52}) is $0.22B$, therefore, the request of N_8 of $path_{852}$ is

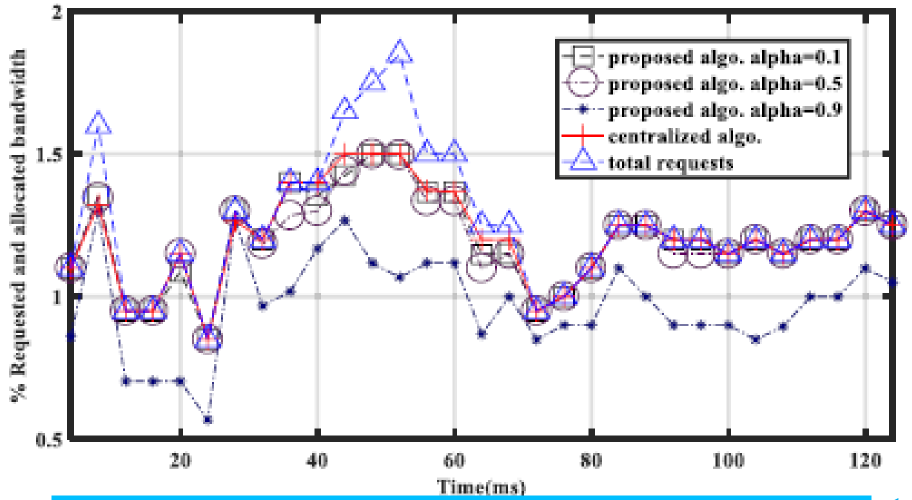


Fig. 9. Effects of chance probability level α on resource allocation.

the allocated bandwidth are updated periodically in the topology. Therefore, the resulted shortage can be avoided in the subsequent frames.

6.4. *Probability level effects*

In the proposed model, we considered single chance constraint stochastic optimization problems, and for the sake of simplicity, we considered the same value of probability level (i.e. α) in all the constraints. It is clear, from the chance constraints, that larger probability level values enforce a node to care more about other nodes' demands and generate stricter constrained optimization problems. As a result, a node will request for less bandwidth, considering other nodes' requirements. On the other hand, lower probability levels lead to more relaxed optimization problems and give a node the opportunity to request for more resources and greater freedom in selecting their paths. In order to clarify the effect of the probability level, we simulate the stochastic proposed scheme for three different levels of probability, i.e. $\alpha = 0.1$, $\alpha = 0.5$, and $\alpha = 0.9$. Fig. 9 shows that the higher the probability level gets, the bigger the difference between requested and allocated bandwidth becomes. This can be attributed to the reason that nodes request for less than what they actually need. In Fig. 10, we can see the effect of the probability level on the requested bandwidth by nodes when the selected level is $\alpha = 0.9$. For example, N_6 noticed an expected value of bandwidth of $0.23B$ for L_{53} (denoted by λ_{53}) In this case, and for $\alpha = 0.9$, the node is restricted to request for $0.15B$ of N_3's capacity, while it needs $0.35B$. The same holds for N_8, where it could not request for N_2, N_3 capacities, because it was restricted by the expected values of bandwidth reported for the links L_{952} (L_{95} and L_{52}) and L_{953}

11

Why to do this analysis

Its meaning, How does it matter?

Finding with evidence

An answer to a research question

How to organize the Conclusion section

- The last chance to convince the reviewer/reader of your research

1. Restate **the main topic**, and the importance of your research in your field
2. Restate the key findings and contributions
3. Present how your research is moving your field forward (implications)
4. Present what should be done after this research (future work)
5. Present the limitations of your research
   - Combine them with some sort of defense
   - Combine them with future work suggestions

Conclusion (example)

The proposed algorithm … he average load-based and the instantaneou… needs to periodically (e.g. every 20 *ms* or t… ation about the expected values of allocate… But unlike the instantaneous strategy, there is no need to regularly report the loads to the donor(s), since resource requests are sent and resources are allocated every few numbe… l is s… the simulations. … algo… performs the av… y ab… Fig. 12. It also e… mila… neous strategy d…

The proposed approach

Main findings

Future work and limitations

The main topic
Its importance

It moves the field forward

7. Conclusion

In this paper, a distributed stochastic scheme is proposed to jointly solve the problem of resource allocation and path selection in a mm-wave multi-hop multi-path integrated access backhaul 5G networks. The proposed algorithm can take the place of centralized ones whenever they are not applicable or feasible to implement. The proposed scheme depends mainly on a periodical spread of information about the expected values of the allocated bandwidth for the links in the DAG topology, starting from the roots (donors) of the network and ending at the edge nodes. This information exchange helps the nodes gain a perspective to the network graph and conditions. The perspective obtained significantly helps in solving the problem of resource allocation and path selection in a distributed approach, especially when more than one fiber/operator node is present. The proposed scheme depends on a set of chance-constraints stochastic optimization problems solved in a bottom-up order. Simulation results show that the proposed algorithm gives nearly the same results an optimal centralized algorithm does. Results are affected by the probability levels of the chance constraints. But they generally show that the less the levels get, the less the difference between the requested and allocated bandwidth becomes. For a two-tier network, comparisons have been made between the proposed algorithm and other load-based algorithms. The comparisons show that our algorithm can give better partitioning results than other load-based methods. Finally, as part of our future work, we tend to extend the design of path selection and resource allocation schemes in multi-hop multi-path IAB topologies with multiple donors to accommodate delay sensitive applications. This can be done by including the number of hops to donors in the decision making process.

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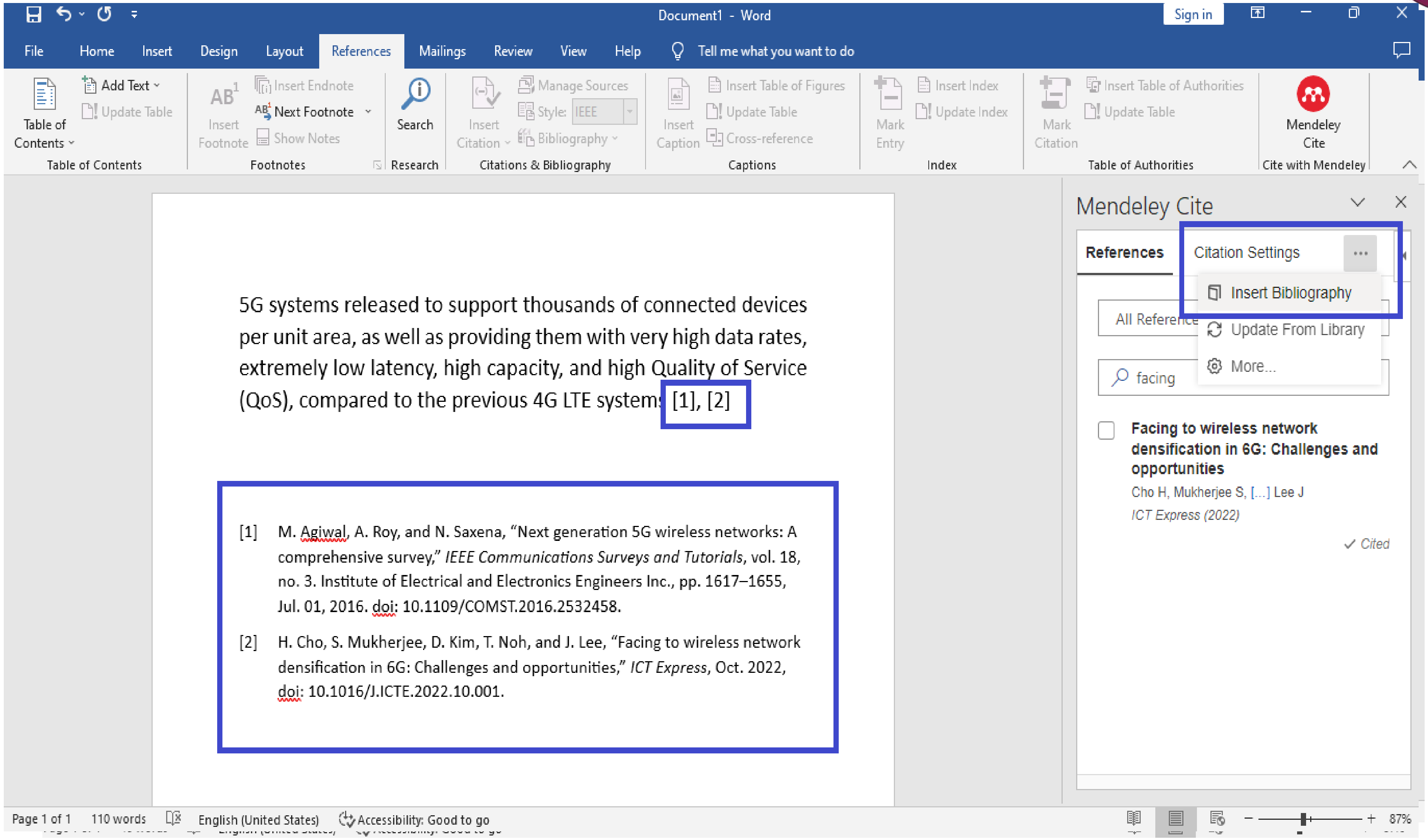
What should the Acknowledgments section include?

- Thank:
  - People who helped you with your study
  - Organizations that funded you
  - Facilities or equipment you used

How to organize the References section

- Determine the source of citing (journal, conference, book chapter, etc.)
- Determine the **referencing style** adopted in the desired journal
  - In text, and references list
  - IEEE, APA, MLA, Harvard, etc.
- Include all the needed elements in the references list
  - Authors, year, title, source, volume, page, doi, etc.
- **Use referencing management tools**, avoid adding references manually
  - Add in-text citations, and update them
  - Generate a list of reference/biographies automatically
  - Mendeley, End Note, Zotero, MS Word

References (example)



Appendices and Supplementary files

- Optional, but help in avoiding charges, saving space, and reusing the data
- Materials that are not essential, but will provide useful information
  - proofs, text, data, tables, figures, video, code, etc.
- You may have several appendices or supplementary files
- Reference appendices or supplementary files as explained in guidelines

General advices

- Select, carefully, the right venue for submission (increase your chance)
- Polish your title, abstract, and cover letter
- Follow the "**Author's Guidelines** " of the journal
- Keywords/title/abstract play a role in acceptance/citation
- Make your sentences short, clear and consistent
- Visualization is important (use tools)
- Reference like a professional
- If at first you don't succeed, learn from rejection and try again
- Go through reviewers' comments carefully, respond directly and calmly

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Thank you for your Attention